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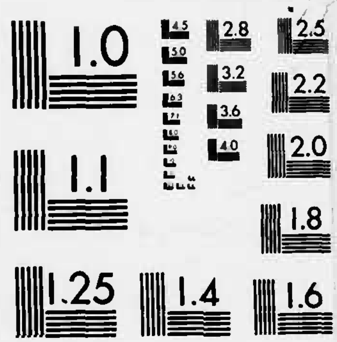

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THESIS

A PERSISTENT CHEMICAL
EFFECTS MODEL

by

Mark Arthur Youngren

June 1983

Thesis Advisor: James K. Hartman

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This thesis presents a high-resolution stochastic combat simulation model which will simulate the effects of a persistent chemical agent attack on a ground force unit. The model is suitable for inclusion in simulations which are capable of tracking individual soldiers and delivery munitions, and can provide explicit ground and air concentrations.

This model will simulate the immediate measures taken by a soldier in response to a direct or indirect persistent chemical agent threat, such as

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masking, donning protective clothing, immediate decontamination, and first aid. It will compute the dosages received from multiple agents. These actions are performed in response to probabilities and probability distributions which are inputs to the model.

This thesis includes an implementation of the model written in the SIMSCRIPT II.5 programming language for inclusion in the Simulation of Tactical Alternative Responses (STAR) model.

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A Persistent Chemical Effects Model

by

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

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ABSTRACT

This thesis presents a high-resolution stochastic combat simulation model which will simulate the effects of a persistent chemical agent attack on a ground force unit. The model is suitable for inclusion in simulations which are capable of tracking individual soldiers and delivery munitions, and can provide explicit ground and air agent concentrations.

This model will simulate the immediate measures taken by a soldier in response to a direct or indirect persistent chemical agent threat, such as masking, donning protective clothing, immediate decontamination, and first aid. It will compute the dosages received from multiple agents. These actions are performed in response to probabilitites and probability distributions which are inputs to the model.

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I. INTRODUCTION

The renewed interest in recent years concerning the problems associated with chemical warfare has sparked an interest in modeling the phenomena and including such models in various analytic combat models and combat simulations. Chemical warfare modelling has become an essential adjunct to combat simulation. Current modelling efforts are focused on the integrated battlefield, where nuclear and chemical threats are presented alongside conventional battles.

A military chemical agent is a toxic substance designed to incapacitate or kill and may be dispersed using a variety of delivery means, predominantly indirect fire artillery and missile systems. The chemical agent may be dispersed as a liquid, vapor, or aerosol and can be classed according to it's persistency of effectiveness on the battlefield. Non-persistent agents are designed to cause casualties by entry into the body through the respiratory system. They are released in vapor or aerosol form, and generally present little percutaneous hazard. Persistent agents are designed to create casualties through absorption into the skin. They are released in a liquid or liquid aerosol form. Persistent agents will generally pose an inhalation hazard as well, particularly under conditions favoring evaporation [Ref. 1].

The significance of the persistency classification lies in the measures necessary to protect the soldier against chemical effects, and the duration of the protection required. Nonpersistent agents normally require only the protective mask as a protective measure, and the duration of effectiveness is measured in minutes to a few hours. Persistent agents, on the other hand, require complete body protection and the effects may last from hours to days. In

addition to requiring protection at the point of release of the agent, persistent agents will contaminate any material coming in contact, so soldiers who leave an area after a persistent agent attack remain contaminated. Once contaminated, they must remain in full protection for a period of up to several days unless the contamination is removed through decontamination.

Unfortunately, the distinction between persistent and nonpersistent agents is not clear cut. The persistency of a given chemical agent depends upon its physical properties, the means of dissemination (delivery), the environmental conditions at the delivery area, and the type and condition of the terrain, equipment, and material that the agent falls upon. Some agents are classified as semi-persistent, indicating that they may be tactically employed either for their inhalation or percutaneous effect and may last for relatively short or long periods of time depending upon the factors given above. The only true nonpersistent agents are those found in a gaseous state under normal battlefield environmental conditions. These include most blood and choking agents. Generally classed as persistent agents are the blister agents, V-series nerve agents, and thickened G-series nerve agents, while unthickened G-series nerve agents are often classed as semi-persistent. Again, these classifications may change under different conditions [Ref. 2].

Persistent agents create the most problems in tactical situations because of the problems associated with the protection required and with contamination. Persistent agents may be employed in order to present these problems rather than to cause casualties (although casualties are an obvious secondary benefit). They may be employed in areas without troops in order to create contamination.

A. APPROACHES TO MODELLING PERSISTENT CHEMICAL AGENTS

There have been several approaches taken toward modeling the effects of chemical agents on the battlefield. The traditional approach has been to determine aggregate casualties (in percentages) to a unit attacked with a given number of chemical munitions, which is dependent upon parameters such as target size, type of agent and munition, protection afforded the troops and environmental conditions at the delivery area. This approach may prove useful in high-level, low resolution combat models where the basic combat entity is a unit. However, it ignores some significant effects of chemical agent employment and creates problems in disaggregation in models where individual entities or small groups such as crews are modeled.

The casualty approach ignores the effects of contamination and reduced personnel effectiveness due to full chemical protection. It was mentioned before that persistent agents may be employed to produce this effect rather than casualties. The impact of persistent chemicals upon the individual soldier is discussed in more detail in the next chapter. The important thing to realize is that the effects created by the presence of a chemical agent are as important as the effects caused by the agent penetrating the body, causing casualties through its toxic effect. Models in the past few years have increasingly included the chemical protective level as a fundamental environmental parameter and have included the effects of protection and contamination in various ways.

The percentage casualty approach toward modeling chemical agent effects is generally unsuitable for low-level, high resolution models that track individual soldiers as basic combat entities. It is not difficult to disaggregate when all of the individuals in a unit are basically

interchangeable, for example, in a dismounted infantry company (even there, there are distinctions between the weapons employed). However, the scheme becomes harder to apply when individuals are different; for example, distinguishing between the driver, loader, gunner, or commander of a tank. Stochastic assignment is possible but this tends to ignore differences in protection between individuals. As a result, an approach that measures the effect a chemical agent will have on each individual, based on his own level of individual and collective protection, is more suitable for high-resolution simulation.

When considering the question of how to model the dosage received from a chemical agent, two approaches present themselves. One approach involves the use of the simulation event scheduling capability of the SIMSCRIPT language [Ref. 3]. As each initiating event occurred (for example, the impact of a chemical round), reactive measures could be scheduled as a result of this event. There are, however, several problems associated with this approach. If the person encounters a chemical agent as a cloud or when crossing chemically contaminated terrain, there is no set time at which he may detect the presence of the chemical agent and react accordingly. As a result, the model would have to check frequently to see if the situation favors scheduling a detection event. The dosage received by an individual exposed to a chemical agent depends upon the times at which the individual took actions to reduce that exposure; for example, masking and decontaminating. However, the scheduling of these events may depend upon the dose accumulated because the individual may first detect the presence of a chemical agent when he shows symptoms resulting from exposure. Thus, another problem with this approach is the interdependence of dosage with individual protective reactions. It is possible to handle this problem

by updating the dosage whenever any event occurred which would affect the dosage received, such as masking, etc. However, a periodic update would still have to be scheduled to check if the dosage accumulated was sufficient to initiate events. This creates another problem, which is calculating the deposition or airborne concentration of agent at the individual's location. If an event-initiated approach is used, it will be necessary to be able to compute the dosage at any time at any location. Most models create an entire grid of deposition when called. Thus, either this grid would have to be called repetitively after very short time intervals as each individual had a triggering event, or an individual time and space approximating heuristic would have to be applied between periodic updates.

The other approach, which has been adopted in this model,is to conduct a check of every individual on the battlefield periodically and update the times that actions would have occurred accordingly. This periodic check can be scheduled every time the deposition patterns are updated, negating the requirement for continuous refreshment of the deposition patterns. The update examines the situation as it appeared during the period since the last update and decides if any action, such as detection, should have occurred in that interval. If so, it will schedule all events initiated by that detection sequentially into the future. The actions predicted by the update can be continuous in time. The only slippage that occurs is the length of the update interval -- which should be relatively brief. The times of actions and reactions must be accessed by the dosage calculations, and they should be accessible outside the module for use in the main simulation. In order to accomplish this, the times that individual reactive protective measures are taken are assigned to attributes of each person. This attribute related approach also allows the model to schedule events in

the future, in terms of assigning a future time value to an attribute. These values can be accessed at a later time and used to make dosage or other calculations.

B. AN OVERVIEW OF THE PERSISTENT CHEMICAL EFFECTS MODEL

1. Capabilities of the model

The model will simulate the following actions taken in response to a chemical hazard or which will occur when a persistent chemical agent is present:

1. Detection of the chemical agent, from:
   a. Chemical agent alarms or detectors.
   b. Presence of suspicious physical signs.
   c. Warning from a nearby person who has detected the presence of a hazard.
   d. The appearance of visible symptoms.
2. Automatic masking and increase in chemical protection as dictated by doctrine and training.
3. Masking and increases in chemical protection due to:
   a. Orders.
   b. Detection of the chemical hazard.
4. Seeking or creating temporary overhead cover.
5. Immediate individual decontamination of skin and clothing.
6. Injection of a nerve agent antidote, to include wrongful injection.
7. Changes in collective protection.
8. Decay of agent due to weathering.
9. Dosage of chemical agents accumulated internally, as a function of:
   a. Individual protection.
   b. Collective protection.
   c. Leakage (if any) in protection.
   d. Decontamination.
   e. First aid administered.

f. Air and ground concentration.

g. Agent type.

h. Chemical situation; i.e., moving or stationary; in area of direct effects, indirect effects, or contamination.

i. Time.

10. All of the above can occur in a multiple agent environment. The maximum number of expected agents must be established at the beginning of the simulation.

The model can handle many different combinations of personnel, equipment, or doctrine by varying the user-input parameters which establish all equipment characteristics, probabilities of taking alternative actions, and distributions of times of actions taken. This provides a large degree of flexibility in fitting it to a particular main combat simulation and a scenario.

The model provides the following outputs for each individual soldier through attributes:

1. Accumulated dosage for multiple agents, updated at a user-defined interval (10 seconds or less).
2. Individual protection status for 7 different body areas.
3. Collective protection status.
4. Threshold dosage for each different agent for impairment, incapacitation, and death.
5. Chemical detection status of individual.
6. Contamination / deposition on exterior of protection.
7. Leakage rates of individual protective items to liquid and vapor hazards.
8. Times at which the following events were completed or reached:

a. Latest change in individual and collective protection, for each item of protection.

b. Contamination of the individual or his vehicle.

c. Individual decontamination.

d. The detection of a chemical hazard.

e. Nerve agent antidote injection.

f. Reaching the impairment or incapacitation threshold for each agent.

g. The occurrence of death.

2. Limitations

The model is limited by its scope and some of the assumptions made. Some salient points are mentioned here.

The model does not translate the actions taken internally to the main combat model. An interface will need to be made, unique to each implementation, which queries (through attributes) the chemical model about the actions taken and the times at which those actions occurred or were completed. This information should be used to affect the combat performance of the individual in the main simulation. A possible delay of up to DELT seconds (the user-defined interval at which the model is called) may occur. Most actions are scheduled by the chemical model to occur in the future, but those that began during the DELT look back cannot be accessed until the end of the update. For example, the model determines that detection occurred at the previous update time TL; masking is scheduled and is completed at time TL + 8 seconds. This information is not available until TL + DELT seconds (the current time) - if DELT is 10 seconds, there is a 10 second lag in the detection event and a 2-second lag in the masking event. This delay should not normally be significant but this is the reason for the recommendation that DELT be 10 seconds or less.

The model will increase the level of chemical protection automatically but will not decrease it. The reason for this is the long delay after contamination occurs before it is safe to remove protective clothing. It is fairly simple to have the protection reduced on order

(see the chapter on model enhancements) but the decision logic for that order is not present in the model. In fact, although the model will respond to directed changes in protection the procedure for making that decision will have to be modelled separately (it has not been included - this enhancement is probably implementation-specific).

There is no decontamination beyond the immediate individual decontamination contained in the model. This is suggested as an extension (see Chapter 4).

The data requirements placed on the user form both a capability and a limitation on the model. On one hand, the model is very flexible and can respond in many different ways as desired. This makes the model useful for a variety of combat simulations and scenarios. However, there is a significant time investment involved in determining the appropriate parameters and some information may not be available. Many models bypass this by hard coding various assumptions or distributions. This permits the user of such a model to avoid the effort of determining these parameters, but forces him to accept the hidden assumptions. The user of the model presented in this thesis may make the simulation and inputs as simple or as complex as time and resources allow.

3. Model Requirements

The model described in this thesis is a high-resolution model designed to be called from a high-resolution combat simulation. It can be implemented with any model that:

1. Tracks individual soldiers as combat entities.
2. Is capable of describing the protection, both individual and collective, of each soldier at any given time.

3. Is capable of identifying the time and location of every incoming round or delivered attack (chemical or conventional).
4. Is capable of providing a pattern of chemical agent deposition and cloud spread at frequent, periodic times.

Although not a requirement, the model is designed to be implemented in SIMSCRIPT and uses the attribute and set membership capabilities of that language. A specific implementation of this model written in SIMSCRIPT has been included. It is designed to be used as a module within the Simulation of Tactical Alternative Responses (STAR) model resident at the TRADOC Research Element, Monterey.

4. A General Explanation

The model presented in this thesis is designed to predict the accumulated dosage of chemical agent received by any individual modeled in the main combat simulation. It models the actions performed by an individual after encountering a persistent chemical agent hazard from any source. The model will simulate both immediate threats posed by direct chemical attacks upon ground troops, and residual hazards posed by downwind travel of chemical agent clouds and contamination of terrain.

The model requires an explicit input of the air concentration in milligrams / cubic meter, and the ground deposition in milligrams / square centimeter at each grid coordinate at each update time. In the STAR model, this is provided by a modified version of NUSSE II [Ref. 4], which provides concentrations and depositions in an irregularly spaced grid pattern, with uniform concentrations assumed within a grid square. This model, or one like it, should be called to update the ground and air concentrations at each iteration.

The initial chemical agent effects begin at the time of impact of a chemical munition or the time of dispersion of agent. Since the most common means of delivery to front-line positions will be artillery, and since it is the only delivery system currently modeled in STAR capable of delivering chemical agents, artillery is the assumed means of delivery for the purpose of alerting troops of the possibility of an attack. Other delivery means, such as aerial spray and chemical mines, can be modeled in terms of their chemical effects, and the delivery can be added without too much effort to the model framework. Enhancements to the basic model are discussed in Chapter 4.

The area of direct attack is considered to be the area within which troops may react to the attack without any indication of its chemical/nonchemical nature. Within the model, it is defined as the area within which an individual may be exposed to a hazard from exploding, conventional munitions. He will therefore take ordinary protective measures, such as hitting the ground or seeking cover.

The remaining areas of interest are the areas of initial and secondary liquid deposition outside of the direct effects ellipse, the area of downwind spread from initial attack area, and the areas of residual contamination. Possible downwind effects from residual contamination are assumed negligible.

The model is designed to handle simultaneously multiple chemical agent classes. The deposition for each agent and accumulated internal dosages are computed separately, with no interaction. It is possible to increase the time required to decontaminate two or more agents simultaneously through a user-defined parameter. Synergistic effects are ignored, but reactions will occur based on the first agent hazard detected or suspected.

The model is designed to simulate the reactive measures taken by two or more sides. The logic of reacting to a persistent agent attack tends to be the same regardless of nationality, as described in Chapter 2 (Doctrine). The probabilities of taking several different alternative actions, based on training, doctrine, and the situation, are contained in user-input global variables which are dimensioned by the number of sides. Also, descriptive variables, such as alarm thresholds and the protection afforded by chemical protective garments are similarly dimensioned. It is possible to play two sides (e.g., RED and BLUE) or more than two (joint exercises involving allied forces with different doctrine and/or equipment).

All effects are computed at the end of a user-defined interval of time (on the order of 10 seconds or less). All individuals on the battlefield are updated each time; events that occurred within the interval are assigned absolute times of occurrence stored in attributes of the person. These attributes can be accessed external to the model to compute the effects on combat performance caused by the use of chemical agents.

When a given round or volley impacts (or ejects chemical agent), reactive measures taken by troops exposed to the hazards may begin. The deposition model will provide a model of the travel of agent vapor and liquid to the ground and downwind.

In general terms, the model does the following: At a set time interval, a routine (CHEM.CHECK) is called and performed for all individuals alive on the battlefield. The routine checks to see if the individual has been exposed to any chemical agent hazard since the last update. This hazard could be from a chemical attack, movement of a chemical cloud over the individual's position, encountering a cloud or contaminated terrain while moving, or from previous

contamination. If he has been exposed to a chemical hazard, dosage will be assessed according to his exposure and protection level during the interval since the last update. In addition, the model checks to see if the individual will react to the chemical agent threat. This reaction could be initiated by a conventional attack (due to doctrine), the suspected detection of a chemical agent based on physical signs, detector paper or kits, alarms, nearby soldiers detecting the agent, or the appearance of symptoms. The precise actions taken will be dependent upon the initiating event, the current level of protection (collective and individual), and the doctrine involved, which is established by setting probabilities upon alternative courses of action. In addition, some actions may automatically trigger others. For example, performing decontamination automatically causes the donning of chemical protective gear after the completion of decontamination.

There will be several probability distributions determining the time at which a unit (person) notices the attack. At this point, the given individual will take protective action in accordance with his degree of protection. Once he has assumed a protective posture, he can warn others nearby of the attack. The detection event can be triggered by chemical agent alarms - when an alarm is triggered, it will automatically cause all persons within a set distance to notice the attack. The actual time that a given individual notices the attack is the earliest of three times - the time he would have noticed it by himself, the time a nearby person detected the attack, or the time a nearby alarm was sounded. The latter two times are adjusted for distance.

The major effect of the hazard presented by the vapor produced by a chemical agent attack will be to change the individual and collective protection categories of

adjacent units, resulting in degradation caused by the protective gear (not modeled). If the vapor cloud reported by NUSSE II (or some equivalent deposition model) travels to a unit area before that unit has increased its protective level to at least the minimum required to prevent the chemical agent from entering the body, then the model will handle dosage and other computations as if the unit had been attacked with the appropriate concentration of agent.

Normally, units crossing an area of chemical contamination will assume full individual protection prior to crossing (or seal themselves within vehicles with positive-pressure filtration systems). If the unit assumes such protection, the only dosage received by individuals will be that resulting from leaks in the chemical protection caused by combat hazards, tears, improper decontamination or donning, etc. The vehicles and all persons not inside sealed vehicles will be regarded as contaminated for the remainder of the simulation.

The amount of agent picked up onto vehicles, equipment, and personnel can be set through a user-defined parameter to be a percentage of the deposition on the ground. This pickup factor is used whenever the unit is passing through an area of old deposition; if the agent is still falling towards the ground, the unit is assumed to receive the current deposition.

If the unit does not assume chemical protection prior to entering the contaminated area, then individuals will begin to receive dosage as soon as they cross the threshold of the contaminated area (some arbitrary level will have to be set as the outer limit of effective contamination). At some point they may notice the contamination (the detection process being similar in concept to noticing a direct attack) and take the same protective and decontamination measures as if they had been directly attacked. Delay

times and dosage received will be handled using the same routines used for the direct attack. Some assumptions have been made regarding the amount of contamination on soldiers if essentially all of the agent has settled on the ground at the time of entering the area (see Chapter 3, Section B).

When actions are predicted based on an event such as a detection that occurred during the interval since the last chemical update, times that each action would be completed are stored in attributes of the person involved. These times are later referred to in the present or future iterations of the routine to figure the protection available to the individual for dosage calculations, and also to predict the likelihood of follow-on events.

The model does not attempt to translate the actions taken by the individual soldier, or the dosage received by him, into actions that will affect the main combat simulation. These translations would be model specific. For example, a soldier cannot fire, acquire targets, etc. during the time that he is masking. A check needs to be made in the routines that simulate these actions in the main simulation to see when the individual does these things in order for them to affect the combat processes. The model does, however, provide the necessary information for such translation through the values assigned to attributes. These times can be accessed by other routines in the main simulation to affect other combat processes, such as target acquisition, movement, etc. Also, the level of protection can be changed external to the model as reaction to command decisions, actions affecting other elements of the same unit, changes in mission, etc. This change in chemical protection is caused by accessing an attribute that stores the level of protection to which the individual must go; then these changes are later assigned completion times in the same manner as if they were in reaction to a real or perceived threat.

5. Outline of Thesis Documentation

This thesis provides documentation of the basic model and also its implementation in STAR. The next chapter, Chapter 2, describes the current doctrine for reacting to persistent chemical agent attacks, and some of the pertinent problems that the model must address. Chapter 3 outlines the model itself, and provides the logic in a series of flow-charts. It is recommended that a new reader interested in the model capabilities for possible implementation read only the outlines at the beginning of each routine description, and then skip to Appendix B, where input requirements and instructions are stated. Chapter 3 can later be read in more detail after the requirements have been examined.

Chapter 4 discusses possible model enhancements and extensions, and gives recommendations for further modeling efforts.

The appendices provide the detailed information on model inputs and outputs, to include user-defined parameters and general definitions. The SIMSCRIPT routines for the STAR module are documented, and problems unique to the implementation of this model in STAR are discussed.

II. DOCTRINE FOR REACTING TO PERSISTENT CHEMICAL AGENT ATTACKS

The doctrine for reacting to a persistent chemical agent attack is largely driven by logic. The immediate reaction of a soldier, regardless of his training or nationality, will be to cover all areas of the body that are susceptible to the toxic effects of the chemical agent. With persistent chemical agents, this means covering all areas of the body with a chemically- impermeable garment as well as protecting the respiratory tract from airborne hazards.

If it were always possible to detect the presence of a chemical agent before there was any significant exposure to it, chemicals would not pose a significant threat in terms of incapacitation and lethality. However, it is often difficult to detect the presence of a chemical agent from physical signs or other signatures noticeable to the unaided senses. If one waits to react until symptoms appear, a dose sufficient to cause impairment has been reached, and this impairment may delay reaction. It is also possible that a severely incapacitating or lethal dose of agent can be absorbed prior to the appearance of gross symptoms.

A soldier, therefore, is presented with a dilemma. On one hand, he does not wish to react prematurely, as the chemical protective garments will hamper his ability to perform combat tasks. On the other hand, he wants to assume this protection prior to exposure to chemical agents. The tactical doctrine of various nations has evolved to try to cope with this dilemma.

One obvious way for a commander to be able to minimize losses due to persistent chemical agent attacks is to place all soldiers in a protective posture prior to any possible

attack. However, there are many potential drawbacks to doing this. A major problem in moderate to hot temperatures is heat stress. Due to the semi-permeable or impermeable nature of chemically protective garments, it is possible to generate a significant heat load while wearing them, particularly with strenuous tasks, high temperatures, and humidity. It is possible for heat stress to cause more casualties on a battlefield than any other cause. Additionally, there is some sensory impairment associated with chemical protective gear, particularly the mask. Vision and hearing are impeded; eating and possibly drinking cannot be accomplished while wearing the mask. Personal hygiene normally requires removal of some if not all of the protective garments. As a result, there is a tactical tradeoff between the amount of protection worn during periods when there is no immediate threat, and the mission to be performed. In the United States, the doctrine associated with this is called the Mission-Oriented Protective Posture (MOPP), which directs the commander to establish a level of protection for his troops based on his perception of the threat, the environment, and the tasks to be performed by these troops. Military forces of other nations use their own terminology but all recognize the existence of this tradeoff and allow the commander to specify the level of protection for his troops within doctrinal guidelines [Ref. 5].

Once a protective level has been established, there are certain tactical situations that direct a soldier to increase his level of protection without orders. One obvious situation is detecting the presence of a chemical agent. This detection may be reasonably certain or merely suspected, based upon the detection of suspicious signs (to include the presence of smoke), instruments capable of detection such as alarms and detector kits, and the appearance of symptoms. However, detection may occur too late to

prevent exposure. As a result, certain other tactical situations may be specified by doctrine to trigger reactive measures. Because the two predominant chemical agent delivery systems are artillery and aircraft, soldiers may be directed to increase protection whenever they receive incoming artillery or a spray or bomblet attack by aircraft [Ref. 6]. The probability of this reaction, as well as the extent of the reaction, can be established explicitly in the model.

After the individual has assumed an appropriate level of protection, if he has reason to suspect that the attack involved a persistent chemical agent and that the agent is still falling toward the ground (for example, a spray attack or an indirect fire attack where the agent remains suspended in the air for a noticeable period of time), the soldier must seek some type of overhead cover if he is not already under some. Overhead cover can be reached by entering a vehicle or a bunker , building, or other fortification. If such cover is not nearby, cover can be improvised by covering the body with a poncho, shelter-half, chemical protective cape, or other such material. After overhead cover has been reached or created, decontamination can commence if necessary. All doctrine normally calls for the immediate decontamination of exposed skin. In addition, if there is an area of the body that will soon be covered with a chemical protective garment, it should be decontaminated also to prevent trapping agent under the protective garment. This action may be delayed by the tactical situation, but normally skin decontamination is accomplished immediately and decontamination of clothing and gear that will be covered by a protective garment is accomplished shortly thereafter [Ref. 7].

It is apparent that there is a decision to be made by the soldier. If he suspects that he has been contaminated, and he was not in full chemical protection, he must decontaminate prior to assuming any protection other than the protective mask. On the other hand, if he is reacting to a situation such as indirect fire where immediate contamination is not suspected, he will increase his protection without decontamination. The precise weighting doctrine places upon these alternatives will vary from country to country, and the probabilities should be adjusted accordingly.

Reducing the level of chemical protection, once assumed, is a rather long and drawn-out process. The absence of a chemical agent threat, due to decontamination or in cases where it was suspected but not present, must be verified by detection apparatus. This is a time consuming process, and will not be accomplished under normal circumstances while conducting a combat mission. Because most high resolution models such as the STAR model play scenarios of relatively short duration, reduction of protective posture has not been modelled.

Once an individual is in full protective posture, it is still possible to receive a chemical agent dose. One possibility is the presence of chemical agent trapped under the protective garment due to inadequate decontamination or assuming protection without decontamination. Another possibility is the presence of leaks, caused by poor fitting or improperly donned garments and masks, or by tears caused by wear, accidents, and combat hazards. This leakage is not necessarily detectable by the individual. It is also possible for chemical agents to penetrate the protective clothing after a long period of time.

One of the actions taken by a soldier after contamination will be to perform partial decontamination of his equipment, vehicles, weapons, etc. This is normally done upon command by all members of a unit, rather than as an individual (although some national doctrine may call for a certain amount to be done automatically). At some later date, after the unit has performed its combat mission or as time allows, the unit may move from areas of contamination and go through complete decontamination of all personnel and material. If the unit had become contaminated, this is normally the only way that soldiers may reduce their individual chemical protection. (Under certain conditions, it is possible that partial decontamination, combined with weathering, may permit removal of protective gear. However, this will take a relatively long period of time). Partial and complete decontamination have not been addressed by this model because of the directed nature of these actions.

III. THE PERSISTENT CHEMICAL AGENT EFFECTS MODEL

A. INTRODUCTION

The persistent chemical agent effects model described in this thesis is designed to predict the accumulated dosage of chemical agent received by any individual modeled in a high-resolution simulation such as STAR. In doing so, it also models the actions performed by an individual after encountering a chemical agent hazard, whether it is from a direct attack by a chemical round or volley, or from encountering a cloud of agent or contaminated terrain.

The model can be called when the first appearance of a chemical agent appears in the main combat simulation. At that time, individuals are created as temporary entities with a considerable number of attributes, many of which are used to record the times and types of actions taken to react to persistent chemical agent threats. The model updates the dosage received by each individual at a user-supplied interval of time, DELT, simulates the actions that would be taken by an individual facing a persistent chemical hazard, and provides an indication of when each individual is affected by the chemical agent, which can be used to influence other modules within the main combat simulation.

Immediately before the main model invokes the persistent chemical agent effects model to update the chemical status and reactions of all personnel, the routine ALARM.UPDATE should be called to update the warning status of the automatic chemical agent alarms found on the battlefield. It is assumed that the alarms are capable of warning personnel during the update interval DELT if the agent concentration passes the threshold established for each alarm at any time during the interval.

The main combat simulation model calls the routine CHEM.CHECK iteratively for each person alive on the battlefield at time intervals DELT apart. This routine will perform all the functions described in this documentation either within the routine itself or by calling other routines. The description of the actions performed by each routine, along with the logic described and illustrated in flowcharts, is provided in Section E of this chapter.

B. MODELING APPROACHES

1. Determination of the Deposition of a Chemical Agent on the Person

Once the basic concept of the model had been decided upon, with its capabilities and limitations, it was necessary to determine how to model the various phenomena to be represented. The input available from the main combat simulation helped determine the environmental and physical characteristics. The NUSSEII model, or its equivalent, supplies air concentrations and ground depositions in a grid (constant deposition patterns within the grid) at the time intervals desired. Any individual exposed to the falling agent is likely to vary the aspect angle presented to the agent as he conducts his activities, even over a brief period of time. As a result, the simplification of using the ground deposition value of the grid in which he is located (which is in itself an average) for the deposition upon the exterior of all body surfaces (or the exterior surfaces of the collective protection) was adopted. The deposition upon the individual or collective protection of any person in the initial effects area of a bursting round has therefore been established.

2. Leakage Through Chemical Protection

Unless the collective protection is designed to provide total chemical protection, there will be a certain amount of leakage of both vapor and liquid (in small droplet form) through the collective protection. It was assumed that this leakage could be expressed as a percentage of the concentration or deposition on the exterior of the collective protection. For vehicles, this percentage is a function of the vehicle system and weapon type (which identifies the specific type), the state (open, closed without an overpressure system, closed with an overpressure system), the crew or passenger compartment (where applicable), the agent type, and whether we are examining a vapor or liquid threat. For fixed types of collective protection (bunker, foxhole, or in the open with temporary overhead cover), a different array dependent simply upon the protection type, agent type and liquid/vapor threat is used to compute the percentage of agent that penetrates the protection. For these computations, a building or a foxhole with overhead cover is considered to be the equivalent of a bunker.

3. Pickup and Transfer

An adjustment is made to model the amount of contamination resulting from crossing an area of contamination that has completely deposited itself. A pickup factor is used to compute the percentage of the ground deposition that deposits itself upon individuals or vehicles crossing the contaminated area. This pickup factor is a constant percentage for each agent and for all entities. When vehicles cross, it is assumed that they kick up enough dust, etc. to deposit the adjusted contamination uniformly over the vehicle surfaces. With individuals crossing on foot, this will not necessarily be true. The following approach

was used to model personnel crossing an area of prior contamination on foot: If the soldier stops at any point, or reduces his silhouette by crouching, kneeling, lying prone, etc., it is assumed that he will come in contact with the ground sufficiently to deposit the adjusted agent level over all body surfaces. If, however, he continues moving essentially upright, he will contaminate only his legs, feet, and hands (the latter area compensates for the handling of equipment, vegetation, etc that may be contaminated). Once he stops movement, he will receive the contamination over all surfaces.

4. Agent Decay Due to Weathering

Finally, contamination may be reduced by a decay factor which will account for weathering. This decay factor represents the percentage of the original deposition remaining after the iteration interval DELT. This factor will be normally very close to one, as *DELT* is a relatively short interval (on the order of 10 seconds or less), but this could prove significant over several minutes with semi-persistent agents if the arithmetic done on the computer will allow the fraction to be calculated. The contamination, once assumed over the exterior surface, will not be reduced by more than this decay factor without decontaminating, even if the individual moves to an area where the ground deposition is lighter (this holds true even for a clean area with no deposition).

Explicit representation of vegetation, terrain or weather effects is not included in the model. These may be represented to some extent implicitly in the calculation of ground and air concentrations if the model used permits this.

5. Individual Chemical Protection

Individual chemical protection is modelled by dividing the body into 7 areas. They are:

Area 1 - Top of head, normally covered by helmet.

Area 2 - Face and neck, normally covered by a protective mask or a mask with hood.

Area 3 - Torso.

Area 4 - Arms.

Area 5 - Legs.

Area 6 - Hands.

Area 7 - Feet.

Each of these areas can be covered by an item of clothing or gear that offers a certain protection factor. A protection factor, when multiplied by the amount of liquid agent on the outside of the clothing, yields the concentration of agent that penetrates the item. Exposed skin, therefore, has a protection factor of one, while a perfectly impermeable protective garment will have a protection factor of zero. Standard Mission-Oriented Protective Posture (MOPP) levels or their equivalent can be formed for any force by establishing the seven levels of the protection factors provided by that MOPP. The average amount of skin included in each area can be set at different levels for each side to allow for variations in the amount of coverage for different types of protective gear. The body areas are numbered in the order that they would normally be donned. Because the protection factor is defined in terms of the relative absorption of liquid chemical agents, a separate category of protection against vapors and aerosols is defined for the protective mask. Thus, the mask has two numbers associated with it - the protection it affords the skin against liquid agents, and the protection it affords the respiratory tract and muccus membranes against vapors and aerosols.

6. Collective Chemical Protection

Collective chemical protection (CP category) is divided into 5 categories:

1. Vehicles - closed, equipped with overpressure systems
2. Vehicles - open or closed, with no overpressure system
3. Covered fortifications (bunkers) or buildings
4. Foxholes
5. In the open

The protection afforded by each category is calculated by adjusting the effective ground and air concentrations as discussed above. No time is assessed when changing collective protection categories - if movement is required to go from one to another, then it should be modelled by the main combat simulation in the same manner that all movement is modelled.

7. Detection of a Persistent Chemical Agent

A major factor in modelling the reactions taken to the presence of a chemical agent hazard is the time at which this hazard is determined. The word detection used throughout this thesis refers to the positive suspicion on the part of the individual that he is being exposed to a persistent chemical agent hazard. Once this suspicion is sufficiently strong for the individual to assume the presence of the agent and react accordingly, detection has occurred. This suspicion may be derived from doctrine and training (for example, treating all incoming artillery as a chemical attack) even in the absence of an actual threat. Since verification of the presence of a chemical agent requires time and specialized equipment, no distinction is made between the individual who merely suspects he has been attacked and those who react to more positive evidence, such as the appearance of symptoms, or the sounding of an alarm.

Detection of a persistent chemical agent attack may occur in any of four ways:

1. The individual can detect based on the assumption that a nearby artillery burst was a chemical munition.
2. The individual may note suspicious signs of a chemical attack, based on physical evidence perceived by him.
3. The individual may hear a nearby chemical agent alarm (an automatic alarm or detector, or a manually activated unit alarm), or detect the reactions of persons nearby who have detected the presence of the agent.
4. The individual detects the symptoms of chemical agent poisoning in himself.

The first means of detection is modeled using a two-stage probability, which may be set differently for each side. Each individual has a given probability of assuming a non-persistent threat (or reacting only partially to a persistent agent threat) by masking only. If a given person chooses to mask (or is masked but would have so chosen), then he may also choose whether or not to treat the attack as persistent by donning full chemical protection. The person is considered to have detected the presence of a persistent chemical threat if he chooses the latter option; simply masking will not cause the person to detect. If the user of the model wishes to have soldiers either assume no chemical threat or assume a persistent threat, he may simply set the second probability at one. One exception to the procedure given occurs if the individual is in a pressurized vehicle; if he masks, this is equivalent to closing the vehicle and no further action is required.

The second means of detection based on suspicious physical signs uses a glimpse target detection model [Ref. 8]. The chance of detecting the presence of a chemical agent occurs in discrete glimpses due to the discrete nature of the periodic update. The probability of

detecting the presence of a chemical hazard during the ith iteration of the model, g_i, is drawn from a user-defined distribution. Since this value must be a probability ranging from zero to one, the Beta distribution is recommended as the most general, although the user can substitute another distribution or assume a deterministic value. As a result, the probability of detecting the chemical agent by the nth iteration after the agent first appeared in a significant concentration is:

$$\Pr(\text{detection}) = 1 - \prod_{i=1}^{n} (1 - g_i) \qquad \text{(eqn 3.1)}$$

The third means of detection relies on the physical proximity between individuals (or automatic alarms, which are discretely modeled). If a person or alarm detects the presence of an agent in a given iteration, he (or it) will warn all persons within a set radius during the next iteration, with the time of such detection being dependent upon the distance from the person detecting to the nearest entity warning him. The one-iteration delay makes the probability of detection via this means independent of the sequence in which the soldiers being modelled are updated.

The last means of detection relies on an impairment dose threshold, which is established for each person - agent pair (the means of setting the threshold is discussed later in this section). The impairment state is considered equivalent to the appearance of visible symptoms, thus, when the person passes his impairment dose threshold, symptoms will appear. If he has not previously detected a chemical agent threat, he will detect at the time that symptoms appear.

8. Immediate Reaction Based on Detection

Regardless of the means of detection, the first action taken by the individual will be to mask, if he has not already. The time it takes the soldier to perform this

and all other physical actions is drawn from a distribution supplied by the user for each side, based on the characteristics of the item being donned. The protection afforded by any piece of protective equipment begins at the moment the donning process is complete; this time is stored by the model as the time at which a given item was donned. Because of the definition of the protection factor as given above, donning the mask also means donning the maximum chemical protection for body area two.

In addition, whenever an item of protective gear is donned, there is a probability that the equipment will leak. This probability is assessed, and if the item is to leak, the amount of leakage expressed as a percentage of the outside concentration or deposition is drawn from a user-defined distribution. This procedure is used to account for leakage resulting from tears, combat damage, improper fit or donning, agent trapped under the item, etc.

A common item of doctrine is to reach or create overhead cover when exposed to the direct effects of a persistent chemical agent. This is modeled by setting a probability that any soldier caught in the open or in a foxhole without overhead cover will assume that there is agent present in the air falling upon him. This probability may be set differently for each side. If he makes that assumption, a second probability vector is used to determine which of three possible actions is taken to reach overhead cover. He may seek overhead cover by entering a vehicle, by entering a bunker, or by creating temporary overhead cover in place by drawing a poncho, chemical protective cape, shelter half, etc. over himself. A time taken to perform this is drawn from a distribution depending upon the action taken, and the collective protection category and time at which overhead cover was reached is updated appropriately. One limitation to this approach is that it does not identify

particular vehicles or bunkers into which the soldier may proceed, so it may be difficult to integrate this reaction into the main model. The way to handle such a problem is to only allow the use of temporary overhead cover.

9. Individual Decontamination

Immediate individual decontamination may be performed at two times: Immediately after detecting the attack, as part of the reaction to that detection, or after symptoms have appeared. There is a separate user-defined probability that the soldier will decontaminate when in either of those two situations.

When performing immediate decontamination, all areas of exposed skin are decontaminated first, then all areas where the protection afforded by clothing, etc, is less than that afforded by the maximum level available (the chemical protective ensemble). The face is not decontaminated, as the mask is donned immediately after detection and normally not removed during immediate individual decontamination. The order of decontamination within the category (skin or clothing) is in the numerical order of the body areas. After each area is decontaminated, the chemical protective piece of clothing or gear is donned. Decontamination and donning times are drawn from user-defined distributions.

Decontamination performed after the appearance of symptoms is the same as the immediate decontamination except that all areas of the body (to include the face) are decontaminated. The donning times are doubled to simulate the time required to remove the old clothing.

Because decontamination is assumed to occur under cover, no additional deposition of agent during decontamination is allowed. The calculation of the dosage received during decontamination is discussed in Appendix A. If decontamination is omitted, and contamination of the individual's

skin and clothing has occurred, a leakage factor will automatically be assessed for all body areas for liquid agents to account for the agent trapped under the protective clothing when it is donned.

10. First Aid

The only first aid treatment explicitly modeled is injection of a nerve agent antidote, although other first aid treatments can be added (see Chapter 4). This can be injected wrongfully, that is, without evidence of symptoms, with a set probability when detection occurs or symptoms of any chemical agent poisoning occur. The effect of any first aid treatment is to reduce the effective dosage by a given percentage.

Antidote injection is handled as follows: A certain percentage of all troops in the area of deposition will inject themselves with an antidote for nerve agent (atropine or some other substance depending upon the country) regardless of the type of agent or if they actually receive a dose - this will account for wrongful injection due to poor training or psychosomatic inducement of perceived symptoms. This percentage can be set to zero for troops in full chemical protection. In addition, if the agent is a nerve agent, injection of atropine will occur when the accumulated dose reaches the impairment dose level for the individual. Injection of the atropine will cause reduce the effective IV dose accumulated by the individual by a given percentage.

11. Dosage Accumulation

Dosages are computed by converting the amount of agent deposited on bare skin or inhaled into the lungs to an equivalent intravenous (IV) dose. The conversion is accomplished by using a user-supplied conversion factor for each case and for each agent. The assumption is made that the

absorption of agent through skin and through the lungs occurs at a reasonably constant rate, and that rate can be expressed as a percentage of the deposition or concentration over time.

It is recognized that an identical IV dose will effect different individuals differently. Rather than using the median dose at which a given effect occurs (such as an LCt50, the dose at which 50% of all individuals exposed will die) as a threshold for all personnel, a distribution (most likely normal) is specified by the user for the lethal threshold dosages. Unfortunately, it is not possible to model a continuum of time and dosage related effects, so a set threshold is established at which the individual abruptly is affected at the level specified (is impaired, incapacitated, or dies).

At the time the temporary entity PERSON is created, a random draw from this lethal threshold distribution establishes his unique threshold value, and stores it in an array pointed to by an attribute of the PERSON. Immediately afterward, the impairment and incapacitating thresholds are set by multiplying the lethal threshold by user-supplied constants. For example, impairment may occur at a level that is 40% of the lethal dose, while incapacitation may occur at 65%. The use of constant fractions of the lethal dose to determine lesser dose thresholds, rather than independent draws from different distributions, insures that the dosages are consistent for each individual. The alternative process of making separate draws from impairment and incapacitation distributions may result in anomalies such as the same individual being in the 95th percentile for an incapacitating dose and the 5th percentile of the lethal dose (which could result in a higher dose for incapacitation than for death)!

When multiple agents are present on the battlefield, all dosages and dosage effects are computed separately with no interactions. Reaching the impairment dose threshold results in the appearance of symptoms, so only the first such appearance will trigger a detection event (even if symptoms appear later from a different agent, all reactive measures have already been applied). The dosages are strictly cumulative with no time-related recovery permitted.

C. A GENERAL OVERVIEW OF THE COMPUTER PROGRAM

The routine CHEM.CHECK will simulate the effects of a persistent chemical agent attack on a ground force unit. CHEM.CHECK is called by the main combat simulation for each person (modeled by the entity PERSON) alive on the battlefield. It does this primarily by calling upon other routines included in the model.

The actions performed by each routine are explained in detail in Section E. A general overview of the function of each routine follows:

1. UPDATE - updates depositions at the location of the PERSON concerned, updates certain global variables and arrays, and performs changes in the chemical protection (collective and individual) ordered external to the model.
2. MASKING - simulates donning the protective masks, and determines leakage (if any).
3. OHC - simulates the assumption of overhead cover by entering vehicles, bunkers, or by creating temporary cover.
4. DECON - simulates the immediate emergency decontamination of the skin and clothing.
5. DECON2 - serves as a subroutine to DECON.

6. DEPOSITION - computes the current deposition on the outside of the individual's protective clothing (as opposed to his collective protection).
7. MOPP - simulates donning full chemical protection.
8. DETECTION - decides if the PERSON will detect the presence of a chemical hazard from physical signs or by being warned by alarms or other individuals.
9. NAA - simulates the injection of the standard nerve agent treatment.
10. DOSE1 - computes the accumulated dosage received through the current time.
11. DOSE2 - serves as a subroutine to DOSE1.
12. CHEMCAS.EFFECTS - decides if the PERSON has passed his impairment, incapacitation, or lethal dose thresholds due to accumulated dosages.
13. SYMPTOM.DETECT - schedules detection of the chemical agent hazard and appropriate reactive measures after the appearance of symptoms, if detection haa not occurred earlier.
14. CROSSING - performs the functions of CHEM.CHECK in situations where the PERSON is crossing an area of previously deposited contamination.
15. DOSE3 - computes the accumulated dosages in the crossing situation handled by the CROSSING routine, above.

The sequence of routine calls, illustrated in Figures 3.1 and 3.2, is briefly thus: The routine CHEM.CHECK will:

- call UPDATE, which:
    - calls the deposition model (NUSSE II or equivalent).
    - may call MASKING.
- Evaluate the chemical situation. If the individual is moving across an area of previous contamination, it will call:

- CROSSING, which will handle all subsequent routine calls.
- Check to see if artillery has landed sufficiently close to the PERSON to cause him to take cover (react conventionally). If it has, CHEM.CHECK may:
  - call MASKING.
  - Decide if the person will assume a persistent chemical threat. If he will, the following sequence will be called:
    - OHC
    - DECON
    - MOPP
- If detection was not assumed above, and has not occurred previously,
  - DETECTION will be called. If detection occurs, it:
    - may call MASKING.
    - may call NAA.
    - will call OHC.
    - will call DECON.
    - will call MOPP.
- In all cases except where control has passed to CROSSING, DOSE1 will be called.
- Next, CHEMCAS.EFFECTS will be called.
  - NAA may be called.
  - If symptoms had occurred, but detection had not, SYMPTOM.DETECT would be called.

Many of the routines given in the main flow described above may call upon other routines, as shown in Figure 3.1. The actual routine calls, and the logic that decides if a call is to be made, is given in Section E.

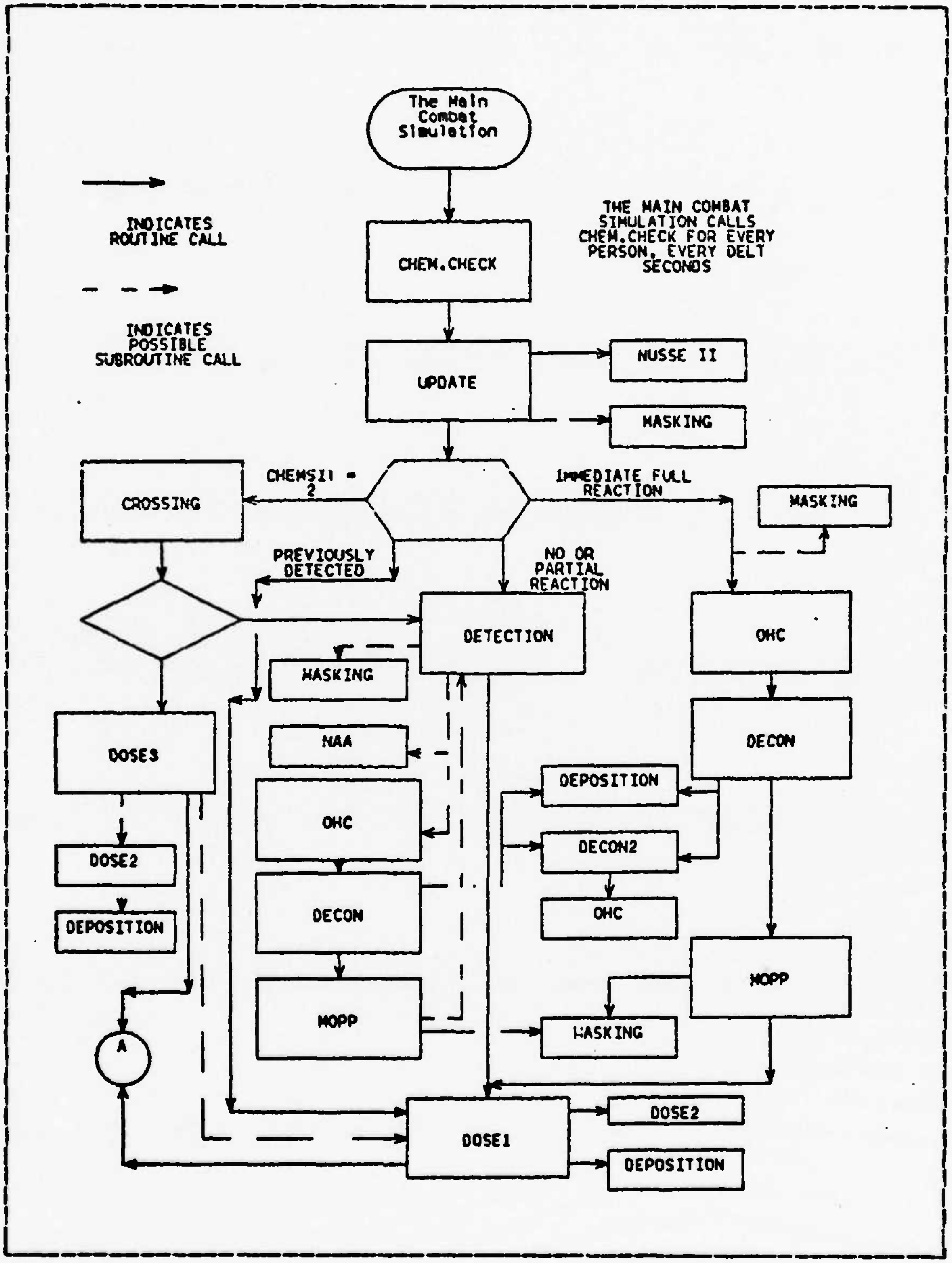

Figure 3.1 Flow of Routine Calls.

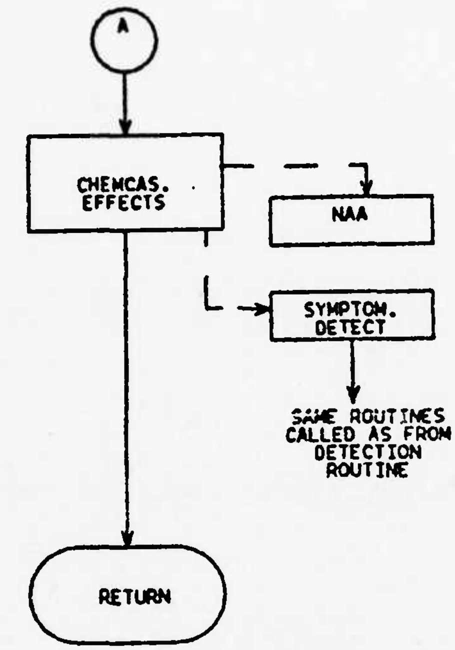

Figure 3.2 Flow of Routine Calls, Continued.

D. DATA STRUCTURE

The model makes extensive use of attributes and global variables. Although some arguments are used between routine calls, because of the complicated structure shown above, this is the exception rather than the rule.

The ability to handle multiple agents and sides required most variables describing the state of the individual or states of nature to be multi-dimensional arrays. Attributes must be singly valued, so many attributes store pointers to global arrays that actually contain the data pertaining to the individual.

There are four broad categories of variables used in the model. They are:

1. Attributes of the temporary entities PERSON, VEHICLE or ALARM. These describe either characteristics of the individual (for example, his individual susceptibility threshold for the various agents), his current situation (his levels of chemical protection, his location, etc.) or the time at which events occurred or actions where completed (for example, the time he detected the presence of a chemical hazard or the time he donned his protective mask). These are generally provided as part of the main combat simulation, although some attributes may have to be provided by the user of the model.
2. Situation variables, such as the type of chemical situation (listed below under the variable CHEMSIT) or the side (force) that the PERSON belongs to. These are generally set within the model.
3. Physical parameters, such as the alarm detection threshold, the absorption rate of the agents through skin, the amount of agent picked up when traversing contamination, etc. These must be supplied by the user of the model.

4. Probabilities and distributions. The logic within the routines is governed by probabilities and probability distributions. These must also be supplied by the user.

A complete listing of the variables is provided in the glossary found in Appendix B. A brief summary of the major variables used is provided below to assist in reading the following documentation of the routines.

1. Attributes of Each Person and Arrays Pointed to by Them:

(The arrays may be distinguished by the extra A added to the prefix)

AG.CUMDOSE, AGA.CUMDOSE - Stores the dosage accumulated by the PERSON for each agent.

AG.IMPAIR, AGA.IMPAIR, T.IMPAIR, TA.IMPAIR - The first two refer to the threshold dosage at which the PERSON reaches impairment; the second two refer to the times at which this occurs for each agent.

AG.INCAP, AGA.INCAP, T.INCAP, TA.INCAP - Same as above, for incapacitation.

AG.LETH, AGA.LETH, T.LETH - Same as above, for lethalities (there is only one time of death).

ANTIDOTE, A.ANTIDOTE - Stores the percentage reduction in the dosage caused by first aid treatment.

CHEM.CHANGE, CHANGE.ORDER - The attribute CHEM.CHANGE points to the array CHANGE.ORDER, which is used to order changes in the chemical protection status from outside the model.

COLOR - Used to identify the side that the PERSON is associated with.

CONTAMINATED, T.CONTAM - CONTAMINATED shows if the PERSON is or is not contaminated; T.CONTAM provides the time of contamination.

CP, T.CP - The collective protection category of the individual and the time that the category was assumed.

DEFNUM - The defilade of the individual, ranging from inside a foxhole (1) to standing up (5).

DEP.AIR, DEP.A.CURR - the current concentration of chemical agents in the air at the PERSON's location. The latter variable does not follow the array naming convention.

DEP.GND, DEP.G.CURR - The current deposition of agents at the location of the PERSON.

MASK, T.MASK - The mask status (on/off) and the time that the mask was donned.

MASKLEAK - The amount of leakage to vapor of the mask.

NAME - An index number used to refer to the individual PERSON.

PF.CHEM, PFA.CHEM - The current protection factors for the seven body areas, and the time that the protective item was donned.

PF.LEAK, PFA.LEAK - The amount of leakage to liquid agents by the protective garments.

ROUND, A.ROUND, RDPTR - The array A.ROUND stores the times and chemical/conventional status of all rounds that impacted close enough to the PERSON during the DELT interval to cause him to react. RDPTR stores the length of the array.

T.DECON - The time at which decontamination was completed.

T.NAA - The time at which an injection of a nerve agent antidote was given.

T.OHC - The time at which overhead cover was assumed.

VEH.SYS.TYPE, VEH.WPN.TYPE - Both attributes of the PERSON, these identify the type of vehicle which he is in (when applicable).

2. Major Global Variables (Other Than Arrays Given Above)

CHEMSIT - The chemical situation of the individual during the current iteration. The various levels are:

0 - Stationary, not directly attacked by chemical rounds.

1 - Directly attacked by a chemical round (stationary or moving).

2 - Moving in an area of previously deposited contamination.

3 - Moving, in an area with a chemical agent present in the air, not directly attacked.

D. prefix variables - These contain or relate to probability distributions, indexed by various parameters. They are:

D.IMPAIR
D.INCAP
D.LETH
D.MSKLEAK
D.PF.LEAK

DT. prefix variables - These each contain a probability distribution for the time it took to perform some action, indexed by various parameters. They are:

DT.DECON
DT.DETECT
DT.MASK
DT.NAA
DT.OHC
DT.PF

DELT - The length of the interval between iterations of the model.

DEP.A.OLD, DEP.G.OLD - The concentrations and depositions for the previous update.

MIN.A.CHEM, MIN.G.CHEM - The minimum significant level of concentration of agent.

N.ALARM, N.VEHICLE, N.PERSON - The total number of the temporary entities ALARM, VEHICLE and PERSON created.

N.SIDE, N.AGENT - The number of sides and agents modeled.

OLD.DOSE - The accumulated dosages at the last update.

OLDCP - The CP category previous to the one the PERSON is currently in, if he changed during the interval DELT (otherwise it is the current CP).

PC. prefix variables - These are used to store the probability of performing some action. They are:

PC.ACT.OHC
PC.DEL.DECON
PC.IMM.DECON
PC.MASK
PC.MOPP
PC.MSKLEAK
PC.NAA
PC.OHC
PC.PF.LEAK

PF.MAX - The protection factors associated with the full chemical protective ensemble.

SKIN - The skin area (square centimeters) associated with each body area.

T.CHEMCURR - This variable serves as a marker for the time at which the latest action performed by the PERSON was completed - used when scheduling sequences of actions.

T.CURRENT - The current simulation time.

TL - The time of the last update.

3. <u>Attributes of Each Vehicle</u>:

NUMBER - an index number used to refer to a specific vehicle.

OPEN.CLOSED - indicates if a vehicle is open or closed (buttoned-up).

4. <u>Attributes of Each Alarm</u>:

WARNING - Identifies if the ALARM will sound a warning (thus alerting PERSONs around it).

X.ALARM, Y.ALARM - The current location of the alarm.

5. <u>Set Ownership and Membership</u>:

Every VEHICLE owns a CREW.

Every PERSON may belong to a CREW.

CREW is used to identify PERSONs who are crew members of the vehicle in which they are riding in (rather than passengers). If the specific vehicle needs to be referenced, the attribute NO.VEH of the PERSON identifies the vehicle number (it is zero if the PERSON is a passenger or not in a vehicle), and each CREW belongs to VEHICLE(VEH.PTR(NUMBER)), the vehicle whose memory address is pointed to by the pointer VEH.PTR, accessed by NUMBER.

The CREW identification is used directly in the model to determine the effective leakage of agent into the vehicle (it may be different in some vehicles for crew members rather than passengers), and it also can identify PERSONs who will not dismount in the main combat situation, and who may be incapacitated or killed when a vehicle is hit. If a crew member should enter or leave a vehicle, the CP change can be accomplished through CHANGE.ORDER but the change in VEH.NO and being filed or removed from the set CREW must be accomplished outside of the chemical agent effects model.

Additional attributes may be desired when implementing. For example, vehicle locations will be needed, and a set ownership identifying the placement of alarm devices may be useful. These may be added depending upon the main combat simulation model used.

E. MODEL ROUTINES

1. The Routine CHEM.CHECK

The CHEM.CHECK routine performs the following tasks for each PERSON on the battlefield:

1. Drives the model and calls all other routines.
2. Updates the depositions, certain global variables, and schedules protection changes on order through the routine UPDATE.
3. Determines the chemical situation faced by each person.
4. Schedules automatic reactive measures (if any) after artillery rounds impact near a position.
5. Schedules a chemical detection, either directly or through a call to the routine DETECTION, based on the situation. When a chemical hazard is detected, schedules the appropriate reactive measures (seeking overhead cover, decontaminating, increasing protection).
6. Updates the dosage through a call to the routine DOSE1.
7. Assigns times at which dosage thresholds are reached, and reactions (if any) to symptoms, through the routine CHEMCAS.EFFECTS.

CHEM.CHECK is the master routine that performs the job of the chemical casualty assessment. CHEM.CHECK is scheduled to be run every DELT seconds after the initial use of chemical weapons (DELT is the time interval delta t between checks - a user input, it is recommended that DELT

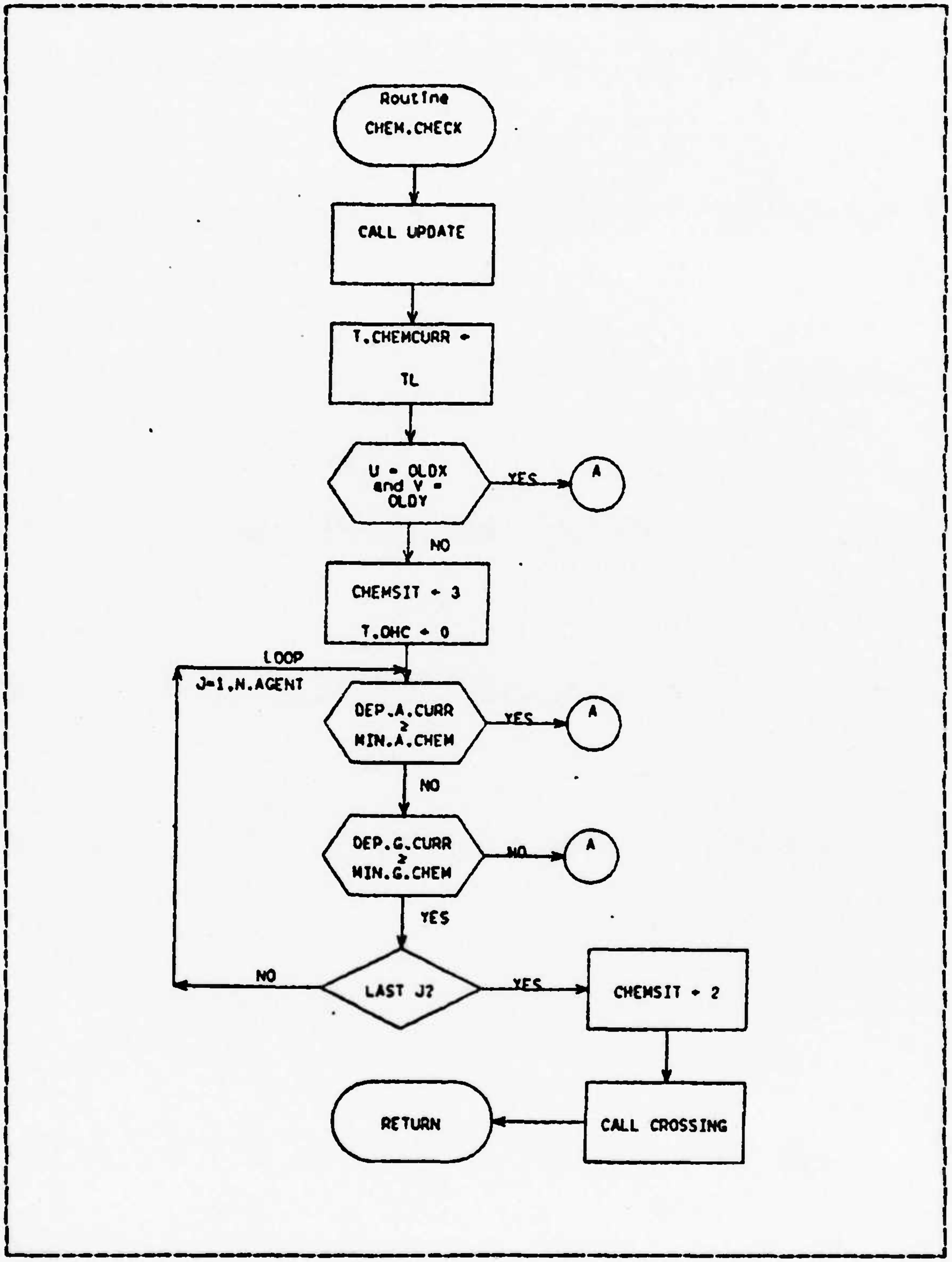

Figure 3.3 Routine CHEM.CHECK.

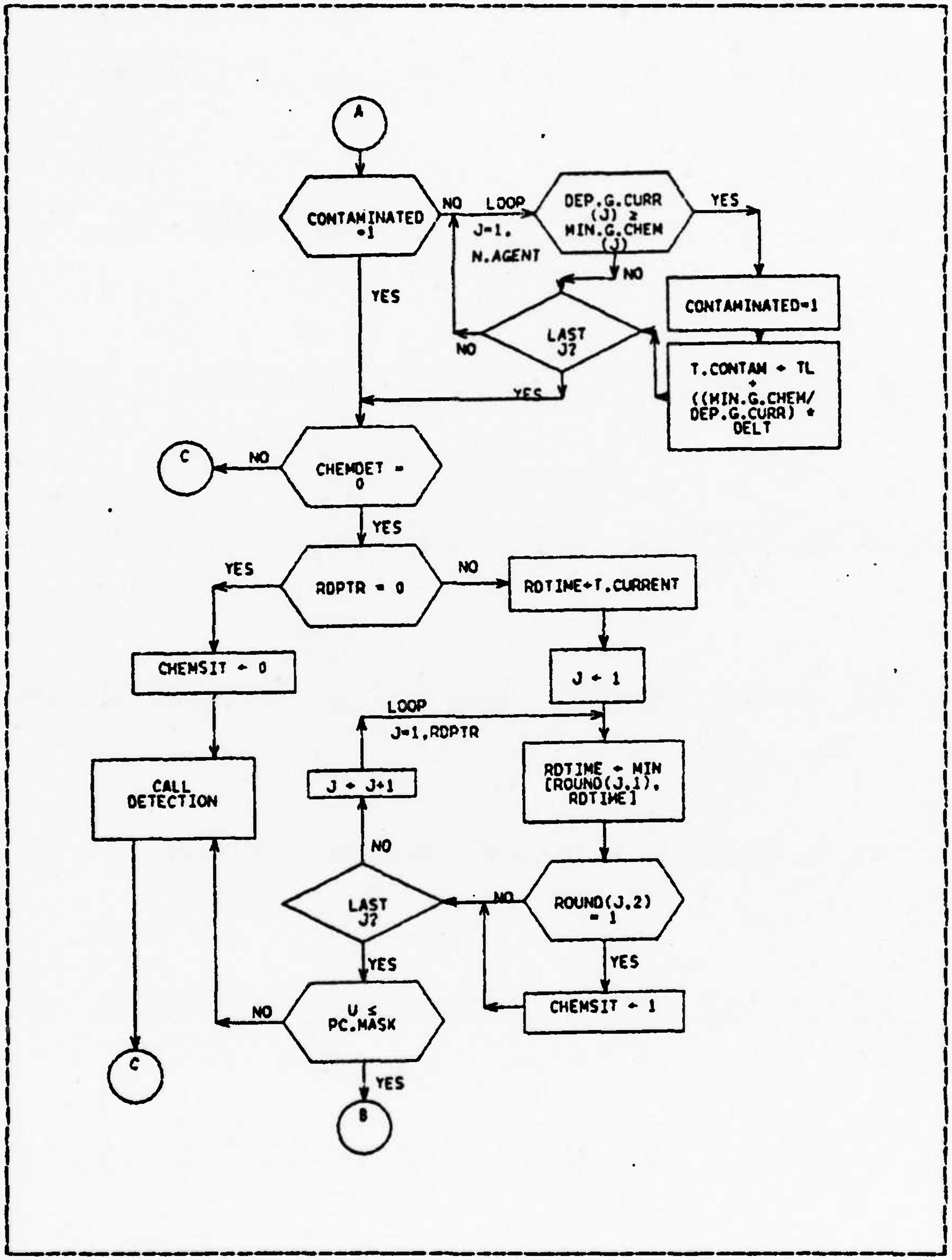

Figure 3.4 Routine CHEM.CHECK, Continuation A.

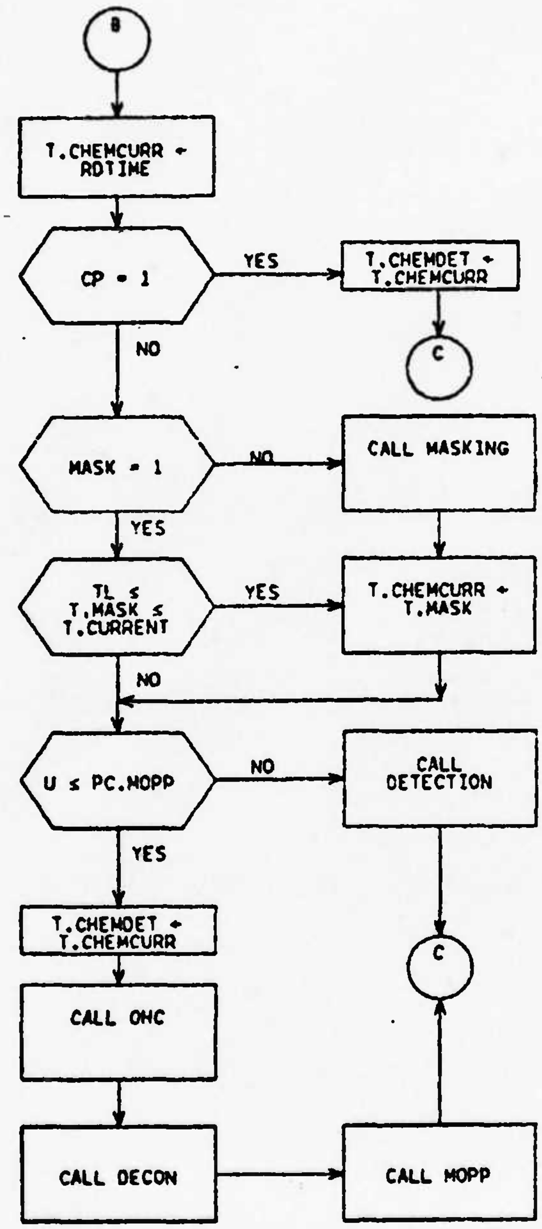

Figure 3.5 Routine CHEM.CHECK, Continuation B.

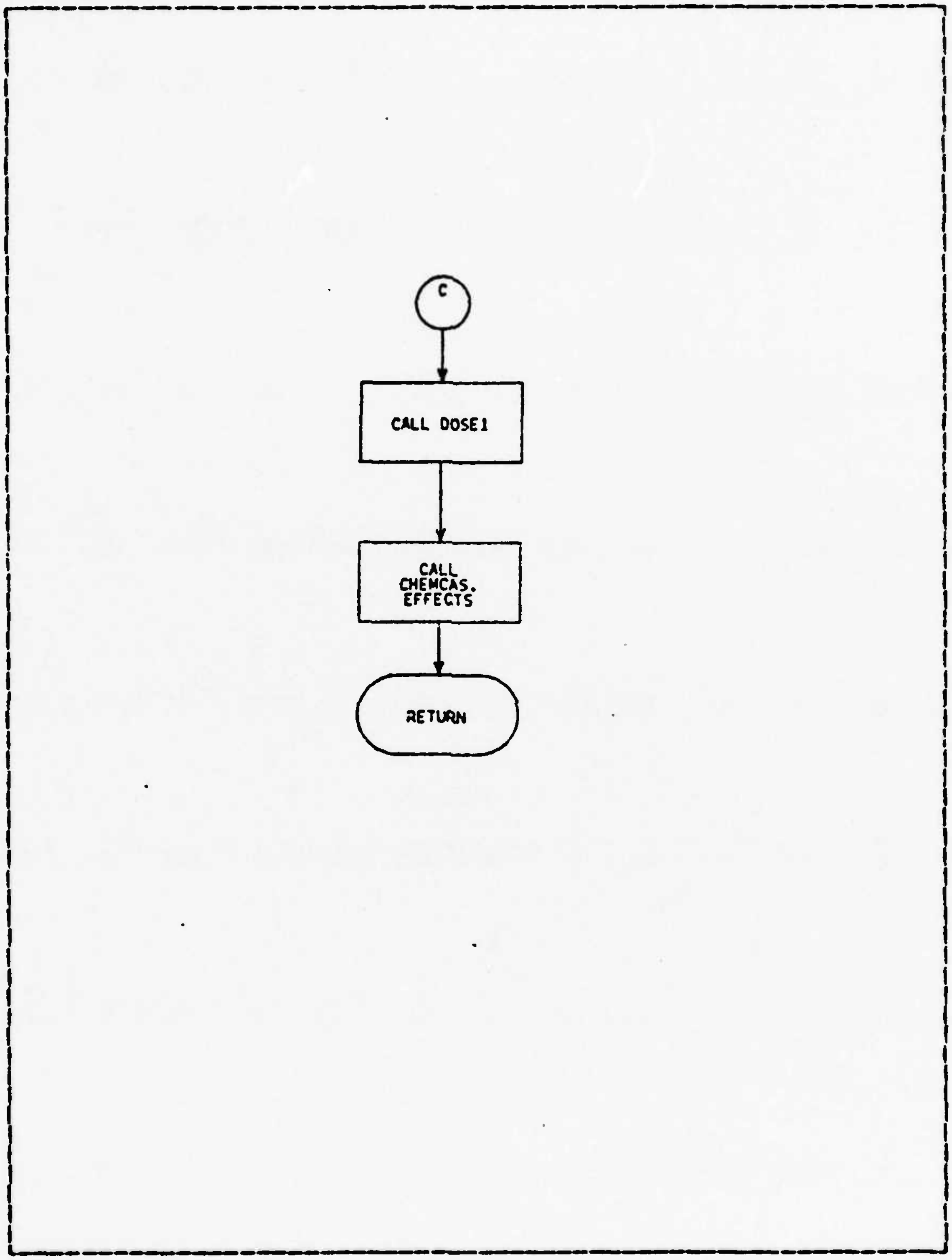

Figure 3.6 Routine CHEM.CHECK, Continuation C.

be less than or equal to 10 seconds in length). The routine is iterated over all PERSONS still living on the battlefield. All events in the routine CHEM.CHECK, and routines called by it, are performed as directed by the logic for each of these PERSONs.

CHEM.CHECK begins by calling the routine UPDATE, which initializes certain temporary variables, assigns the deposition of chemical agent j at the location of the PERSON to the arrays DEP.G.OLD, DEP.G.CURR, DEP.A.OLD and DEP.A.CURR, and checks to see if any changes in protection category or individual protection have been ordered during the previous DELT seconds. The array value DEP.G.OLD(j) represents the deposition of agent j on the person at the time of the previous iteration. DEP.G.CURR(j) represents the current deposition of agent j on the ground at the person's current location at the current update time, and DEP.A.OLD(j) and DEP.A.CURR(j) represent the dosage (accumulated concentration) in the air (at a height of 2 meters) at his location at the last update and the present time, respectively. The current valued arrays have their pointers stored as attributes of the PERSON, so a record is kept of the most recent deposition.

The routine next initializes a temporary variable, T.CHEMCURR, to equal the time of the last CHEM.CHECK (time TL). T.CHEMCURR is used to keep track of the time at which any action scheduled in the routine was completed - thus, it represents the current time for actions performed by the given individual within the routine CHEM.CHECK.

The next actions separate out several possible situations that the PERSON concerned might be involved in. The current situation for the individual, once determined, is stored in the variable CHEMSIT. He may be stationary (no movement in the last DELT seconds), and not directly attacked by a chemical agent (CHEMSIT 0). He may have been

directly attacked by a chemical agent, defined as being inside the ellipse of conventional effects from an incoming chemical round, and be stationary or moving (CHEMSIT 1). He may be moving in an area that has prior contamination, defined as any area where there is agent on the ground but not in the air (CHEMSIT 2). Or he may be moving, in an area with chemical agent present in the air (a chemical agent cloud), but not in the area directly attacked by the chemical round (CHEMSIT 3). These categories will determine the actions taken by an individual, and may change from iteration to iteration because of movement of the person, of a chemical agent cloud, or because of a round landing near enough to be considered a direct attack. If the PERSON is moving, his attribute T.OHC, the time at which he assumed overhead cover, is set to zero because he cannot have temporary overhead cover while moving (see the routine OHC for a further explanation of the significance of overhead cover and T.OHC). If the PERSON is in CHEMSIT 2, the calculations will be handled separately by routine CROSSING, otherwise routine CHEM.CHECK continues.

The routine checks to see if the PERSON has been contaminated at some previous time. If he has not, and his current deposition DEP.G.CURR is greater than a minimum significant level (represented by the global variable MIN.G.CHEM), then he will be marked as contaminated by assigning a value of 1 to the attribute CONTAMINATED and a time of contamination T.CONTAM based on the ratio of the MIN.G.CHEM level to the current deposition level.

If the individual has already detected the fact that he has been attacked by (or exposed to the hazards of) a chemical agent, then the program moves down to the dose computation sequence DOSE1. The reason for this is that all reactive measures caused by a chemical attack are scheduled during the iteration of CHEM.CHECK during which the individual noticed the attack or hazard.

If he has not detected the hazard, the routine checks to see if he was in the immediate effects ellipse of any round during the last DELT seconds - if he was, he might react as if it were a chemical attack. The time of impact of any rounds close enough to have affected the PERSON concerned is stored in an array A.ROUND, pointed to by the attribute ROUND. An additional attribute, RDPTR, gives the length of the round queue. The array A.ROUND also has a (0,1) bit stating whether or not any of those close rounds were chemical - if so, CHEMSIT is updated to be 1. If the individual was not attacked we go to the detection sequence to see if he can detect the presence of a chemical hazard (if any). If the individual was attacked, he may, through doctrine or choice, regard the attack as conventional, rather than chemical. His decision is based on the parameter PC.MASK. If a uniform (0,1) random number is less than PC.MASK, he has regarded the attack as conventional (no chemical-peculiar actions, such as masking, are required). Because this probability is expressed in terms of the attack, rather than each individual round (as a result, the probability is not dependent upon the number of rounds), the routine will then go directly to the detection sequence. If the PERSON regarded the attack as potentially chemical in accordance with doctrine, etc., the current time at which he may react, T.CHEMCURR, is assigned the time of the first round that impacted close enough to react to (which was stored in the temporary variable RDTIME).

The next check is to see if the PERSON is in a closed vehicle equipped with an overpressure system. If he is (CP, the collective protection category, equals 1), then no reaction is necessary since the vehicle is closed and operating with the overpressure system. Since this protection is identical to that required for protection against a persistent agent attack, the PERSON in a CP equal to 1 will

have detected the event, with the time of detection, T.CHEMDET, adjusted accordingly. This process is followed independently for each PERSON, so it is possible that another PERSON in the same vehicle will not have detected the attack. This does not matter, however - the vehicle is closed so the protection enjoyed by any other PERSON in that vehicle is the same, and the DETECTION routine will schedule a time of detection on the next iteration of CHEM.CHECK through proximity to the PERSON who has detected (for further details, see the routine DETECTION later in this section). After his detection status has been updated the routine will go to the dose computation routine DOSE1.

If the PERSON was not in an overpressure system, then the routine checks to see if his mask is on. If not, masking will occur. One possibility that the routine checks for is if the MASK attribute, which determines if the mask is on or off, was just set to 1 (on) during the update routine. If it had been, then the mask will have been donned during this interval, so T.MASK, the time at which masking was completed, may be inside the interval. In either case, the variable T.CHEMCURR, is set equal to T.MASK. This means that any future action scheduled by the routine (such as donning the protective suit) will begin at time T.CHEMCURR, which will be after the mask was donned.

The next question posed by the routine is whether or not this PERSON will react as if the round contained a persistent chemical agent. This question is different from the one posed before, which considered masking on the assumption that there is chemical agent present. Because of the significant drawbacks full chemical protection under many circumstances, (heat stress, etc.), doctrine and/or command guidance may or may not direct that any indirect fire attack be treated as a potential persistent or semi-persistent agent attack; in other words, doctrine may or may

not direct donning full chemical protection immediately after any indirect fire attack. At this point we are discussing possible actions taken by a soldier after a round has impacted in his immediate vicinity, before he has any chance to verify, through detector paper, alarms, or other means, if any incoming rounds contained a chemical agent. The model allows the user to set the probability that the PERSON will react to the attack by donning protective items not already worn through the global variable PC.MOPP. If PC.MOPP = 1, the individual will don full protective gear; if PC.MOPP = 0, then he will not. The user can make this a stochastic event, to account for incomplete reaction to doctrine or training, individual suspicions, etc. by setting that probability PC.MOPP at some intermediate value.

If a uniform (0,1) random number is less than PC.MOPP, then the person will have detected the presence of chemical agent in terms of his future actions - in other words, he has assumed that a hazard is present and will react accordingly. The time of detection, T.CHEMDET, is set equal to his current time (T.CHEMCURR). The routine next calls for the appropriate protective measures based on this detection, which is accomplished by calling the routines OHC to seek overhead cover, DECON for decontamination, and MOPP to don full chemical protection. These routines are called by CHEM.CHECK in that order, and actions are scheduled as directed by the routine's logic. The attributes referring to the time that a given action was completed are assigned values, and T.CHEMCURR is updated to keep the actions in a time sequence. The reader should examine the documentation of these routines later in this section to see how these events are accomplished.

If the PERSON had decided not to mask and/or treat the attack as a persistent agent attack (thereby donning full protection), the routine DETECTION is called to see if

the PERSON will detect the presence of a chemical agent from signs or from proximity to others who have detected (or suspected and thus reacted to) the chemical hazard. The detection routine will or will not schedule a detection during the period DELT according to its logic, then passes the control back to CHEM.CHECK.

If detection had occurred during this DELT period, then all reactions to that attack will be scheduled by DETECTION and other routines, during this iteration of CHEM.CHECK. This may require that events be scheduled to occur at some future time - if it does, future iterations of CHEM.CHECK will check for this by examining the attributes which contain these times and acting accordingly.

After any events that might have occurred in the period DELT are scheduled, the routine DOSE1 is called. This routine calculates the total dose received through inhalation and skin absorption during the period DELT. This routine will check the attributes of the PERSON to see if any changes in protection occurred during DELT (e.g., masking), and adjust accordingly. This dose received during DELT, for each chemical agent, is added to the total dose accumulated as of the last CHEM.CHECK, and stored in the array AGA.CUMDOSE pointed to by the attribute AG.CUM.DOSE.

After the total accumulated dose for each agent has been computed, the routine CHEMCAS.EFFECTS is called. This routine takes the accumulated dose and determines if, based on that dose, impairment, incapacitation, or death could have occurred to that person during DELT. Impairment is defined as the point at which symptoms make themselves apparent to the victim, so further reactive measures are scheduled if the impairment dose is reached during this DELT interval of time. The updating of the times at which these thresholds are reached, for each agent, allows this categorization to be applied to other areas of the model (an

obvious example is removing the PERSON from the appropriate ALIVE set when death occurs).

2. The Routine UPDATE

The UPDATE routine performs the following tasks:

1. Initializes certain global variables to the correct values for the PERSON being examined, such as DEP.G.OLD, DEP.A.OLD, OLD.DOSE, and OLDCP.
2. Gets the current ground deposition and air concentrations. If the deposition is less than that encountered previously, computes the current contamination level on the PERSON, taking into account weathering.
3. Updates CHEMDET, the attribute that gives the detection status of the PERSON.
4. Schedules changes in individual and collective protection (CP, OHC, MASK, and PF.CHEM) ordered by the main combat simulation.

The UPDATE routine is designed to update the deposition and chemical detection status of each individual prior to the decisions and calls made in the routine CHEM.CHECK. It also allows the chemical protection category (individual and collective) to be changed external to the module, by changing values in the 1-dimensional array CHANGE.ORDER, whose pointer is stored in the attribute CHEM.CHANGE.

After the old accumulated dosage values are stored in the array OLD.DOSE, and the old ground and air deposition values have been stored in the global arrays DEP.G.OLD and DEP.A.OLD, the deposition at the current location of the PERSON is set at the current concentration (at z=0 meters for ground and z=2 meters for air) within the grid drawn by NUSSE II. Under normal circumstances, the outside deposition on the individual (that is, the deposition on the exterior of his collective protection, if any, and/or his individual

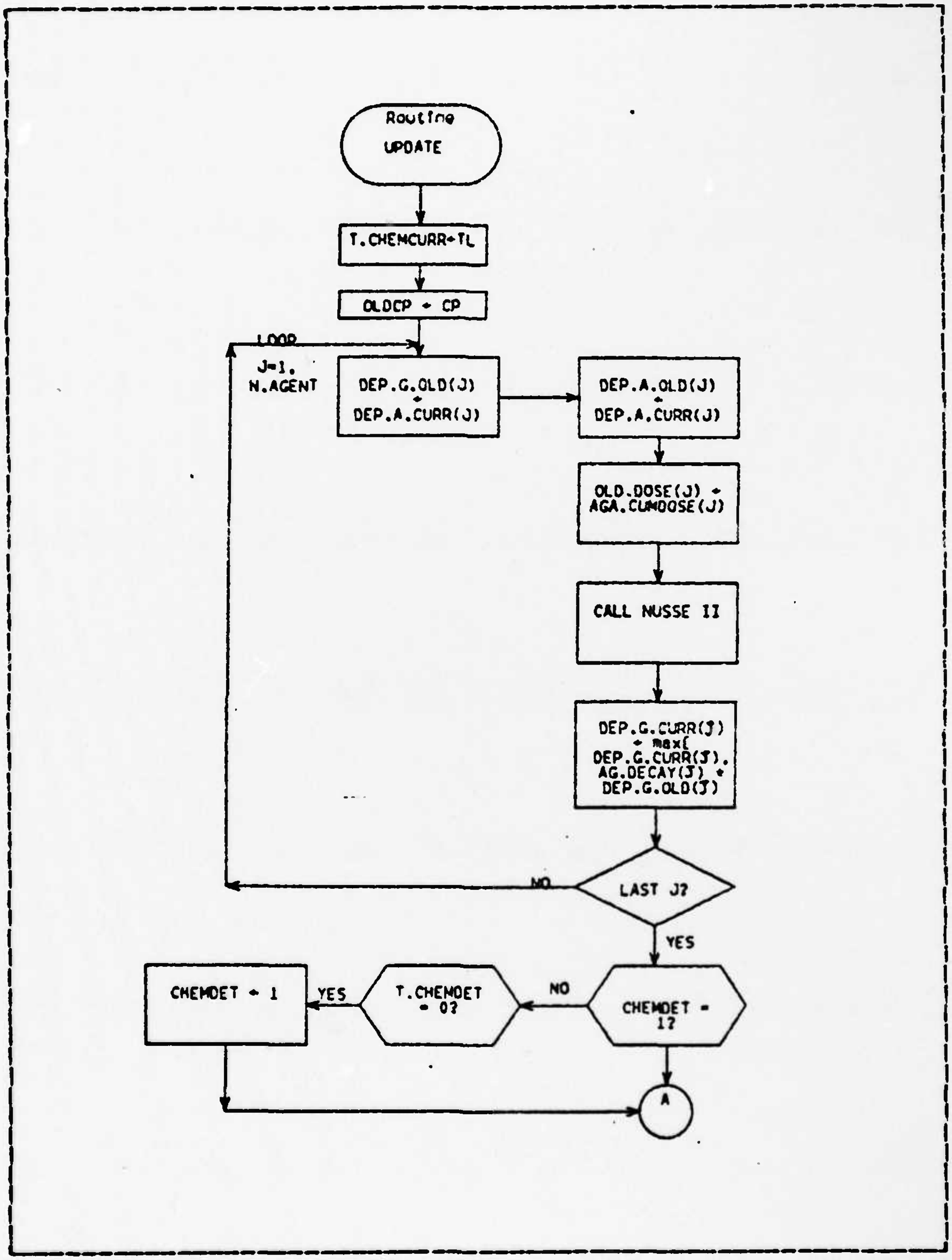

Figure 3.7 Routine UPDATE.

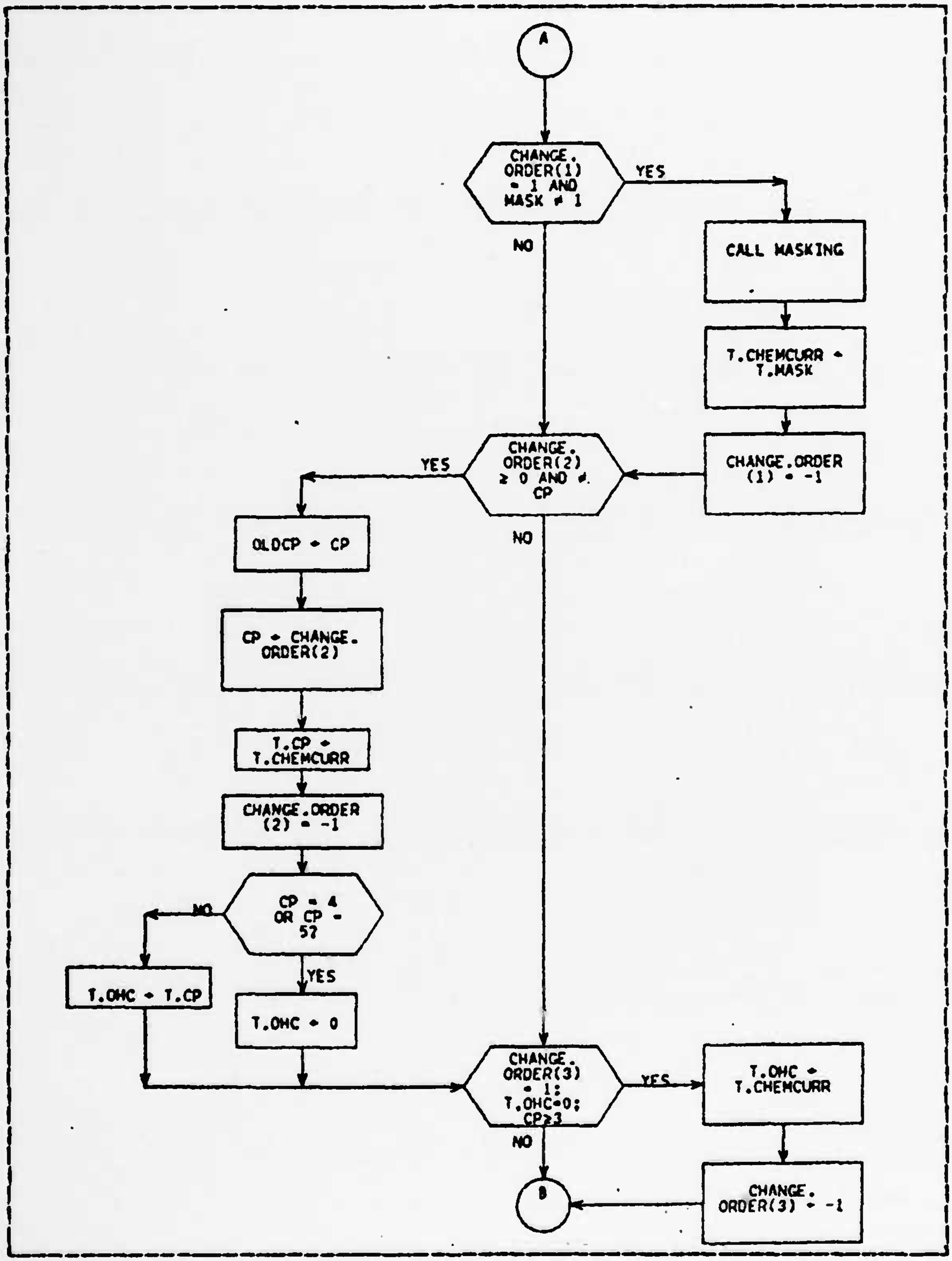

Figure 3.8 Routine UPDATE, Continuation A.

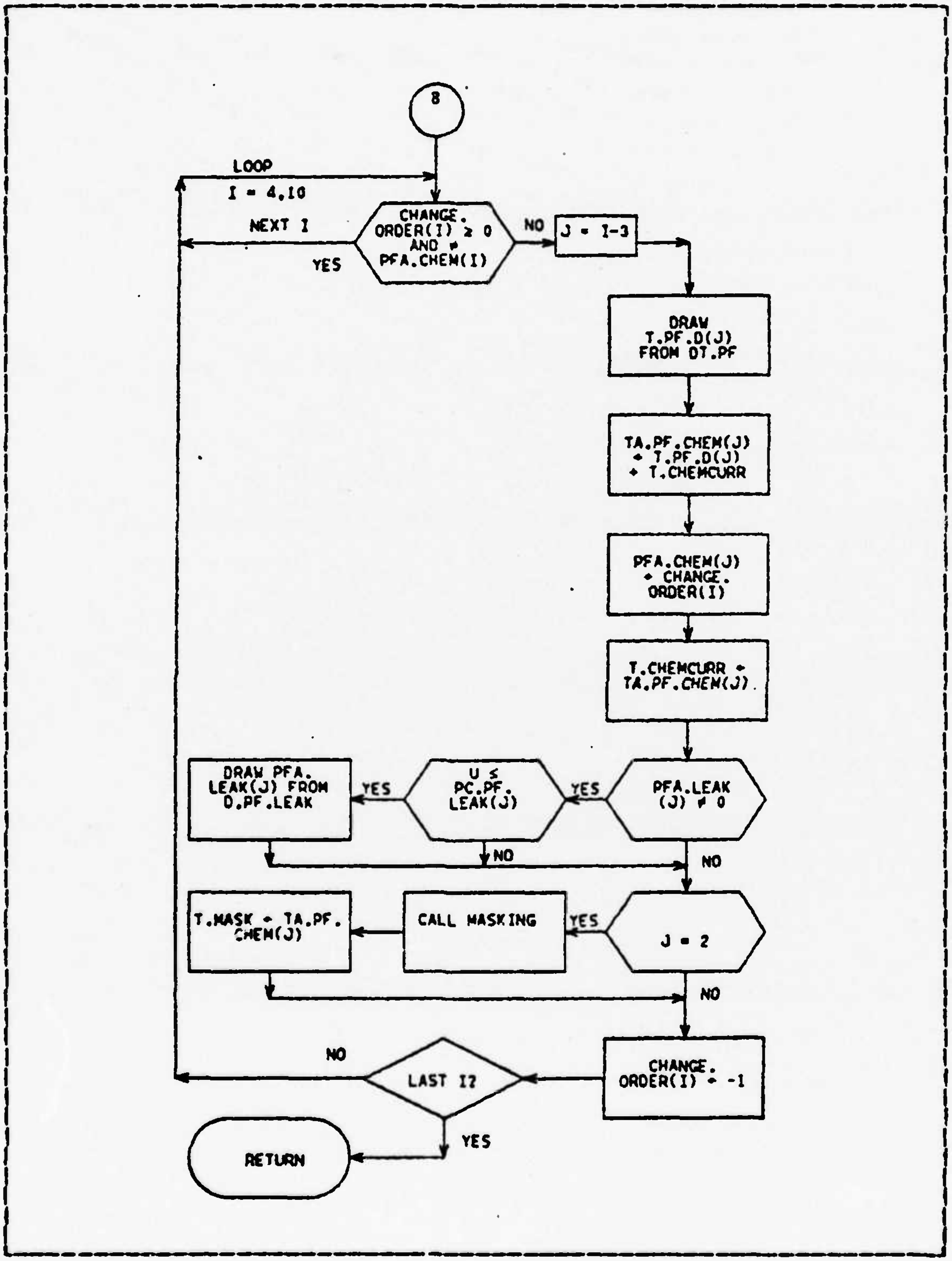

Figure 3.9 Routine UPDATE, Continuation B.

chemical protective garments, if any) is equal to the current deposition drawn from NUSSE II. However, it is possible for the current NUSSE II value to be less than the previous value drawn at the last update if the individual is departing an area of contamination. However, the true value for the individual, rather than the terrain he is standing upon, will continue to be the amount of agent with which he was previously contaminated (as adjusted for decontamination). As a result, the model sets the actual outside deposition DEP.G.CURR(j) for the jth agent at the maximum of the current NUSSE II deposition (the normal case soon after an attack when the agent is still settling) or the previous level DEP.G.OLD(j), adjusted for a decay factor AG.DECAY(j). This latter factor allows for the inclusion of natural weathering factors to reduce the agent deposition over time. AG.DECAY represents the remaining deposition as a percentage of the deposition present DELT seconds earlier. Although this value will likely be very close to one (little decay occurs in less than 10 seconds), it will allow for the inclusion of decay provided the machine arithmetic of the computer upon which the model is run allows this level of precision.

The routine updates the attribute CHEM.DET by assigning it a value of one if the individual had a time of detection assigned (that is, he did detect the presence of a chemical hazard) during the last iteration. This attribute is used to determine if the individual has detected the (suspected) presence of a chemical hazard for purposes of warning nearby individuals.

The last duty performed by UPDATE is scheduling protective status changes ordered externally to the module. Since the last time the routine CHEM.CHECK (and thus the routine UPDATE) was performed, some of the variables of CHANGE.ORDER, stored in the attribute CHEM.CHANGE, may have

been given non-negative values (the array is initialized at -1 for every value). The routine first checks to make sure that the ordered change has not been previously implemented. If it had been, no changes are necessary. If the first variable, CHANGE.ORDER(1) was set at one, the individual was directed to mask. As a result, the MASKING routine is called, the time of masking T.MASK is assigned a new value, and T.CHEMCURR updated to allow for scheduling of subsequent actions in UPDATE (if any).

Changes in collective protection category are considered next. These changes are assumed to be essentially instantaneous for simplicity of calculation. If the change will require any significant time (for example, exiting a vehicle and walking to a foxhole), the intermediate change should be scheduled explicitly (in our example, a CP change from vehicle to in the open is scheduled first (to account for the walking to the foxhole) and the change from being in the open to in the foxhole second). If the change is to CP categories 1, 2, or 3, the overhead cover attribute (OHC) is adjusted as well. The overhead cover can also be changed separately (CHANGE.ORDER(3)=1). This would occur if temporary protection were ordered, e.g., covering a foxhole with a poncho.

Finally, changes in the individual protection for any or all of the seven body areas can be ordered. The new level of protection is specified in the CHANGE.ORDER subscripted variable, so changes to protection levels less than the maximum can be made. This allows the commander to change the individual chemical protective level for all PERSONS in a given unit by changing the appropriate values within CHANGE.ORDER.

After each action directed by CHANGE.ORDER is performed, the array values are returned to -1.

3. The Routine MASKING

The routine MASKING performs the following tasks:

1. Simulates donning of the protective mask.
2. Assigns the time that masking was complete to the attribute T.MASK, updates the attribute MASK and the array values PFA.CHEM(2) and TA.PF.CHEM(2).
3. Determines whether or not the mask will leak with respect to vapor; if it does, determines the amount of leakage and stores the value in the attribute MASKLEAK.
4. Determines whether or not the mask will leak with respect to liquid; if it will, determines the amount of leakage and stores the value in the array value PFA.LEAK(2).

The routine MASKING is used to simulate donning the protective mask. It is called whenever the model events call for masking, regardless of the cause.

The routine determines the time it took this PERSON to don the mask by accessing the global variable DT.MASK, which is a N.SIDE x 3 array. The first dimension contains the number of the side (i.e., the force with which the PERSON is assigned to); the second dimension contains the distribution of masking times (distribution type and zero, one or two parameters). A random number is drawn from that distribution and assigned to the temporary variable T.M.D. The attribute T.MASK, representing the time at which the donning process was completed, is set at the current simulation time for the individual, T.CHEMCURR, plus T.M.D, and the attribute MASK is set at one, indicating that a protective mask is worn.

Because the mask also provides protection to body area 2 from liquid chemical agent hazards, the value PFA.CHEM(2) is updated to show that added protection, and the time TA.PF.CHEM(2) is changed as well.

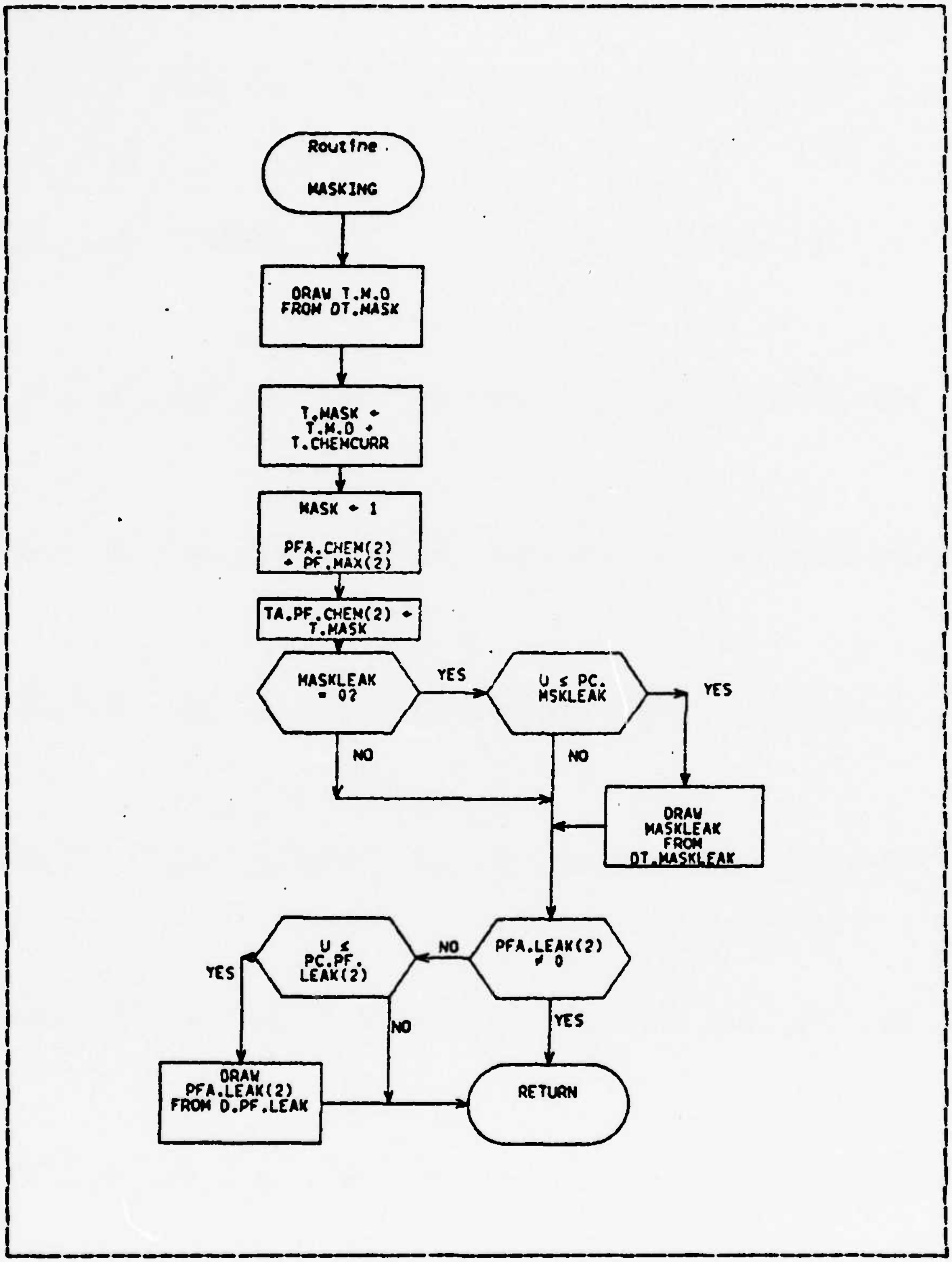

Figure 3.10 Routine MASKING.

Before returning to the calling routine, it must be determined whether or not the mask will leak due to improper donning, agent trapped under the mask, improper sizing, tears, combat damage, etc. If the mask had been tagged as a leaker at some earlier time (for example, this occurs if the PERSON receives some deposition of the agent on his face and dons the mask without decontaminating his face), then this question has been resolved and the routine continues. If, however, the possibility of the mask leaking has not yet been resolved, the probability that this will occur is contained in a global variable PC.MSKLEAK. This is compared to a uniform (0,1) number and if PC.MSKLEAK is greater than or equal to that number, the mask will leak. The amount of leakage, expressed as the percentage of the outside concentration of chemical agent in the air received into the mask, is set by accessing the N.SIDE X 3 global array D.MSKLEAK, and assigning the random number drawn from the distribution indicated by the array to the attribute MASKLEAK. This percentage is assumed to be the same for all airborne agents, since it represents a measure of the amount of agent-laden air bypasses the mask's filter elements.

A similar check is made to see if the mask will leak with respect to liquid hazards. Since the leakage to liquids and vapors is likely to be from different causes, the issues are handled separately. If the mask has not previously been tagged, the variable PC.PF.LEAK(2) is compared to a uniform (0,1) random number. If the mask will leak with respect to liquids, the value of PFA.LEAK(2) is drawn from the distribution D.PF.LEAK.

After these checks have been made, the routine returns to the calling program.

4. The Routine DETECTION

The DETECTION routine performs the following tasks:

1. Schedules, through assignment to the attribute T.CHEMDET, detection of a chemical agent hazard due to physical signs.
2. Schedules detection of a chemical agent hazard due to proximity to a chemical alarm or another PERSON that has previously detected the hazard.
3. Schedules injection of a nerve agent antidote upon detection of the hazard, if desired (this would be a wrongful injection based upon detection, not symptoms of nerve agent poisoning).
4. If detection occurs, calls the routines OHC, DECON and MOPP.

The routine detection simulates the process whereby an individual may detect the presence of a chemical agent through physical signs, such as smoke, vapor, or mist, or reaction to detector paper; through the use of chemical agent alarms; and through proximity to other individuals who have detected such a hazard - hearing their alarm or noticing their reactions (such as masking). The word detection in this context means the creation of a mental attitude or suspicion of the threat sufficient to cause the individual to react as if there was a chemical agent present.

The routine begins by checking to see if there is any chemical agent present in the ground or in the air at the PERSONs location. If there is not agent present, then it is assumed that detection due to physical signs will not occur, and the routine moves down to the point where it begins to check for alarms or persons nearby. If there is agent present, then the array DT.DETECT is accessed. DT.DETECT is a 4 X N.AGENT X 5 X 2 X 3 array which is

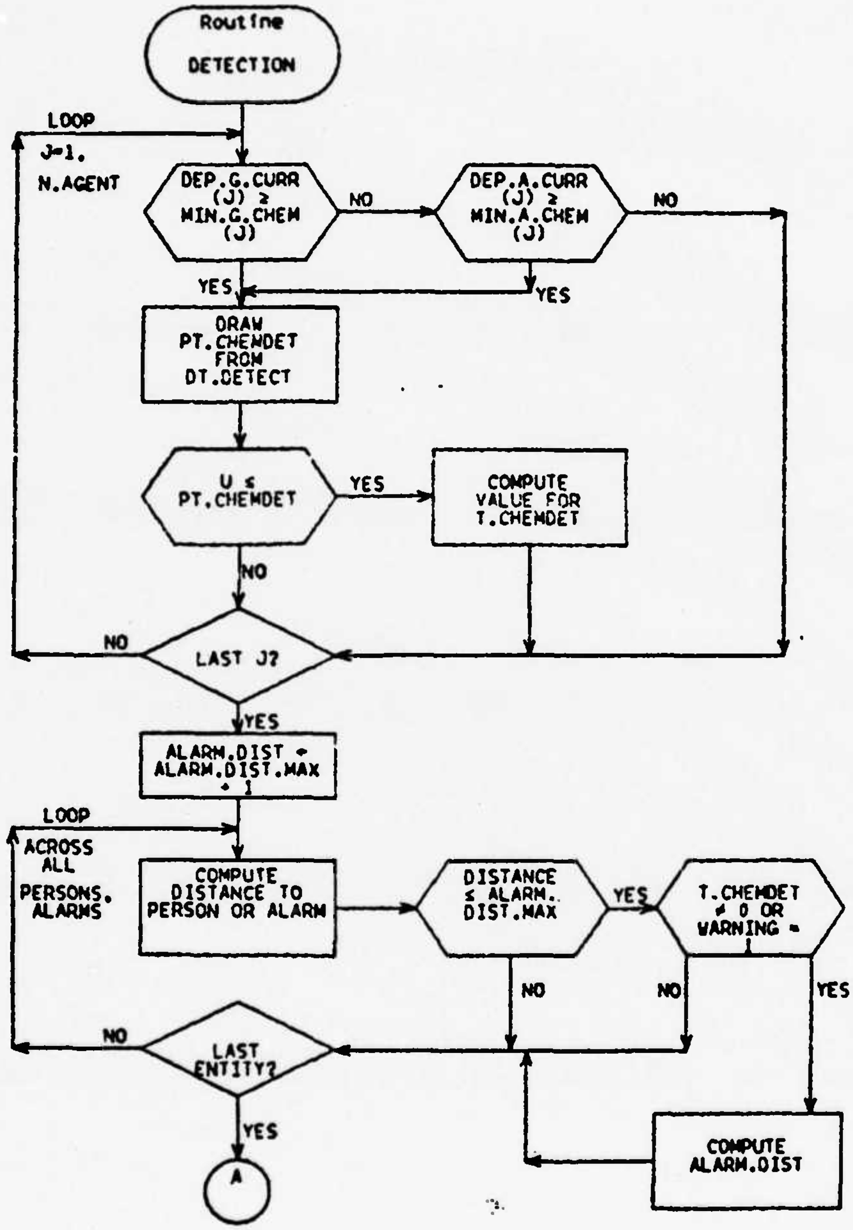

Figure 3.11 Routine DETECTION.

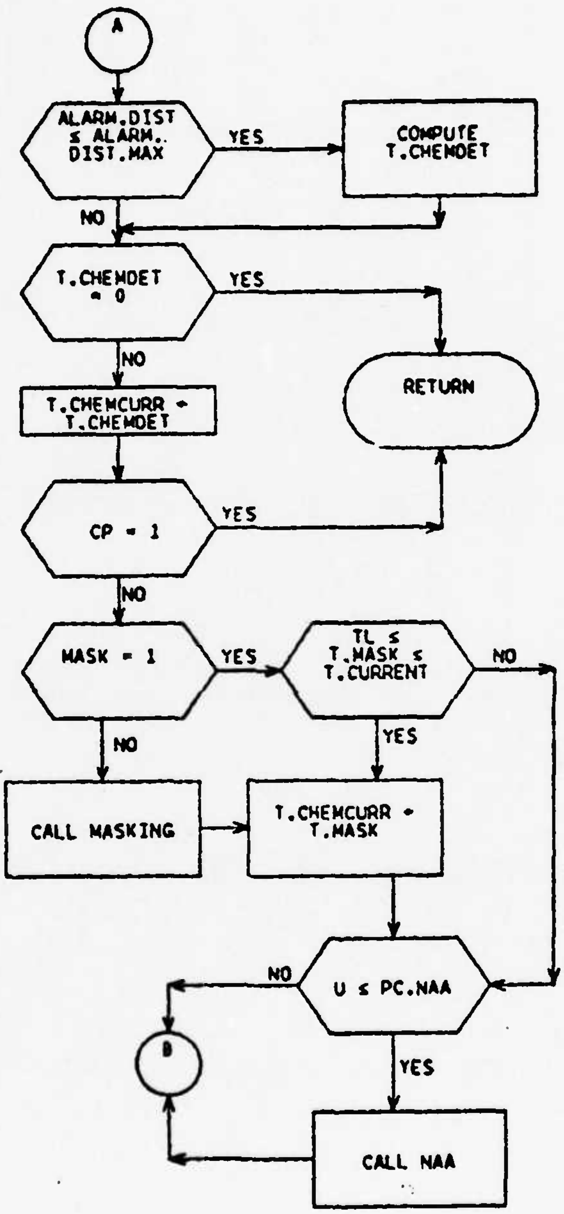

Figure 3.12 Routine DETECTION, Continuation A.

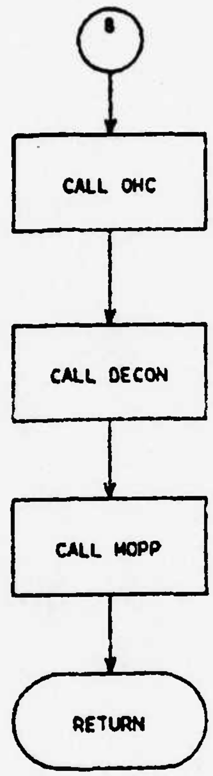

Figure 3.13 Routine DETECTION, Continuation B.

accessed according to the chemical situation CHEMSIT (dimension one), the agent (dimension two), the collective protection category (dimension three), the mask being on or off (dimension four), and the type of distribution and parameters (dimension five). The numbers in the last dimension define a distribution of the probability that the individual will detect the presence of the chemical agent from given signs, under the conditions specified in the other four dimensions, within a time interval DELT. As a probability, the value must be a number between zero and one, so the BETA distribution is recommended as a general distribution which can be fit by the user.

The number drawn from the distribution DT.DETECT is assigned to the temporary variable PT.CHEMDET. PT.CHEMDET represents the probability of detection during this iteration from the glimpse detection model discussed in Section B of this chapter. As such, it is compared to a uniform (0,1) random number to determine if detection occurred during the last DELT seconds. If PT.CHEMDET is greater than or equal to the random number, T.CHEMDET is assigned a value according to Equation 3.2:

(1 - PT.CHEMDET) * (T.CURRENT - T.CHEMCURR) + T.CHEMCURR
(eqn 3.2)

This formula simply assigns the time of detection as the reflected probability times the remaining interval of detection (DELT except when crossing areas of residual contamination) added to the beginning of the interval of detection, T.CHEMCURR.

The above actions are performed for each agent with a significant ground or air concentration present. If more than one agent would have caused detection, T.CHEMDET is set at the earliest time.

The next task performed by the DETECT routine is to determine if the PERSON detected the presence of an agent based on a chemical agent alarm or by noticing a person nearby who has detected the agent. He is allowed to see or hear any other PERSON or ALARM within a distance of ALARM.DIST.MAX (a user-supplied global variable) meters from his position (to simplify matters, his current position for this check is the position at the current update time). In order for a PERSON or ALARM to warn him, it must have previously detected the chemical agent, having a time of detection T.CHEMDET less than or equal to the end of the last iteration (but not equal to zero, which indicates that no detection has occurred). For PERSONs, this means that the individual detected the attack during the previous CHEM.CHECK iteration, which prevents the order of the sequence of PERSONs updated during the current iteration influencing the results (that is, if he detects in this iteration, he cannot warn others until the next, so an individual's chance of detection is independent of whether he is updated before or after another during the current iteration). The ALARMs are updated prior to the PERSONs, so any alarm that sounded during this DELT being examined can influence people nearby.

If one or more PERSONs or ALARMs nearby has detected a chemical agent, than the distance in meters from his position to the position of the warning entity, ALARM.DIST, will be less than or equal to the distance ALARM.DIST.MAX, so the PERSON being updated will have a time of detection assigned to him based on Equation 3.3:

T.CHEMDET = Min (NE 0) [T.CHEMDET, ((ALARM.DIST / ALARM.DIST.MAX) * (T.CURRENT - T.CHEMCURR) + T.CHEMCURR]

(eqn 3.3)

This formula represents the ratio of ALARM.DIST over ALARM.DIST.MAX times the detection interval, which is added to the current simulation time. If the individual happened to detect the chemical agent through physical signs and proximity, he is assigned the earlier of the two times as his detection attribute.

If he failed to detect the presence of a chemical hazard, control is passed back to CHEM.CHECK; otherwise, the current simulation time T.CHEMCURR, is assigned the value for the PERSONs detection time, T.CHEMDET.

If the PERSON is inside a vehicle with overpressure (CP=1), the routine returns to CHEM.CHECK as before since it is assumed that soldiers inside closed vehicles with overpressure will not need to react to the detection event.

If the PERSON is not in a CP equal to 1, then a check is made to see if he is masked. If not, the mask routine is called and T.CHEMCURR is updated. A check is made to see if the MASK attribute is equal to one because of masking scheduled previously (in routine UPDATE or CHEM.CHECK); if so, it is integrated into the current event sequence by updating T.CHEMCURR to that T.MASK value previously assigned.

The next check is made to see if the PERSON will inject a nerve agent antidote based on a panic reaction to the detection of the attack. Doctrine calls for atropine or other nerve agent antidote (depending upon the country) to be injected only after symptoms appear. However, if the user desires, he can cause a certain percentage of the troops to wrongfully inject themselves with antidote by setting a nonzero value to the global variable PC.NAA. If a uniform (0,1) random number is less than or equal to PC.NAA, then the NAA routine is called and injection will occur.

Since the PERSON at this point will have detected the presence of a chemical agent during the iteration (since he has not yet exited the routine), the DETECTION routine will schedule the appropriate reactive measures by calling the routines OHC, DECON, and MOPP. Control is then passed back to the calling routine.

5. <u>The Routine OHC</u>

The routine OHC performs the following tasks:

1. If the PERSON is not already under overhead cover, decides if the PERSON will seek overhead cover inside a vehicle or bunker, create temporary overhead cover, or fail to assume overhead cover (thereby implicitly assuming that there is no persistent agent threat in the air)
2. If overhead cover is created or assumed, draws a time for this to be completed and assigns it to the attribute T.OHC.

The routine OHC is designed to simulate the seeking or creation of overhead cover as a reaction to the detection (denoting a suspicion rather than certainty) of the presence of a persistent chemical agent attack. Doctrinally, if the PERSON suspects that he is being directly attacked by a persistent chemical agent, he will seek overhead cover in the form of vehicles, bunkers, etc., or create temporary overhead cover by covering himself with a poncho, chemical protective cape, etc.

The routine first checks to see if the person is under overhead cover - T.OHC, the time that overhead cover was assumed, is not equal to zero, and/or the collective protection attribute CP is equal to 1, 2, or 3. If the person is not presently under overhead cover, the probability that he will seek overhead cover, PROB, is compared

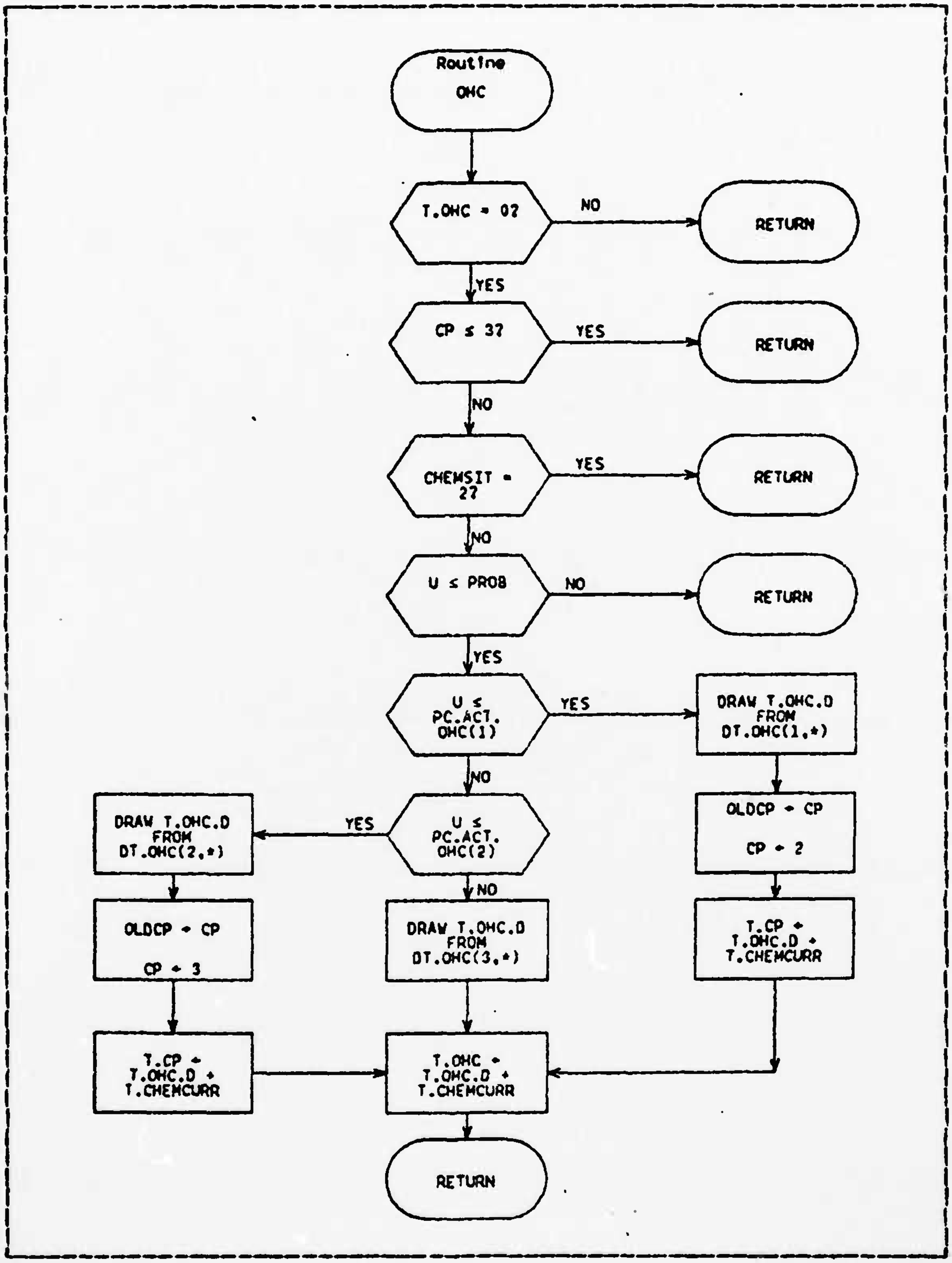

Figure 3.14 Routine OHC.

to a random uniform (0,1) number as before. PROB is an argument passed to it by the calling routine. In all cases except when the OHC routine has been called by the routine DECON2, this variable will be equal to a global variable PC.OHC. PC.OHC is a user-supplied global variable that sets the probability that a PERSON who has been directly attacked by a chemical agent (CHEMSIT = 1) or is receiving indirect fire and is assuming it is a chemical agent, will assume that the threat posed is a persistent agent and that in doing so, will seek overhead cover.

When the OHC routine is called by the DECON2 routine, the value of PROB will be equal to 1, since decontamination will only be performed under some type of overhead cover.

If the PERSON does decide to seek overhead cover (PROB was greater than or equal to a uniform (0,1) random number), he must either enter a vehicle, a bunker, or create temporary overhead cover. As a simplification, it is assumed that the relative probability of choosing one of these three actions can be expressed in a single global variable for all PERSONs. In reality, this would depend on his mission, the distance to vehicles and/or bunkers, whether or not these vehicles or bunkers were filled, etc. and these actions should be tied in with the combat situation represented in the main combat simulation. This detail might possibly be added at a later date as an enhancement to the present model (see Chapter 4). Users concerned about this can set the probabilities of the first two actions to zero and force everyone to create temporary cover.

The probabilities contained in PC.ACT.OHC, the N.SIDE X 2 array that contains the probability of going into a vehicle (PC.ACT.OHC(SIDE, 1)) and the probability of going into a bunker (PC.ACT.OHC(SIDE,2)) for each side. The probability of creating temporary overhead cover is one minus

the sum of the other two. These probabilities are compared to a uniform (0,1) random number to determine the action that will be taken. The time required to assume that overhead cover, given the action taken, is found from the N.SIDE X 3 X 3 array DT.OHC. The first dimension gives the side of the PERSON, the second dimension is indexed by the three actions, and the third dimension gives the distribution and up to two parameters. The value drawn from DT.OHC is assigned to the temporary variable T.OHC.D, and T.CP, the time that the new CP category was assumed (when applicable) is T.OHC.D + T.CHEMCURR. In all cases the time that temporary overhead cover was created, T.OHC, is T.OHC.D plus T.CHEMCURR.

6. The Routine MOPP

The MOPP routine performs the following tasks:

1. Checks the levels of chemical protection stored in the array PFA.CHEM, for body areas 1 through 7, and compares them to the levels of maximum protection, PF.MAX.
2. If any of the levels of protection have associated times indicating that the donning of maximum chemical protection is scheduled (by other means, such as on order) but not yet completed (the time that donning the protection over area i was completed, TA.PF.CHEM(i), is after the current simulation time, T.CHEMCURR), then this scheduled donning is incorporated into the current MOPP sequence by assigning T.CHEMCURR the TA.PF.CHEM(i) value.
3. For areas of the body where the level of protection worn or scheduled to be worn is not the maximum level (full chemical protection), the routine draws the time it would take to don the item from the distribution array DT.PF, schedules the time that the donning would

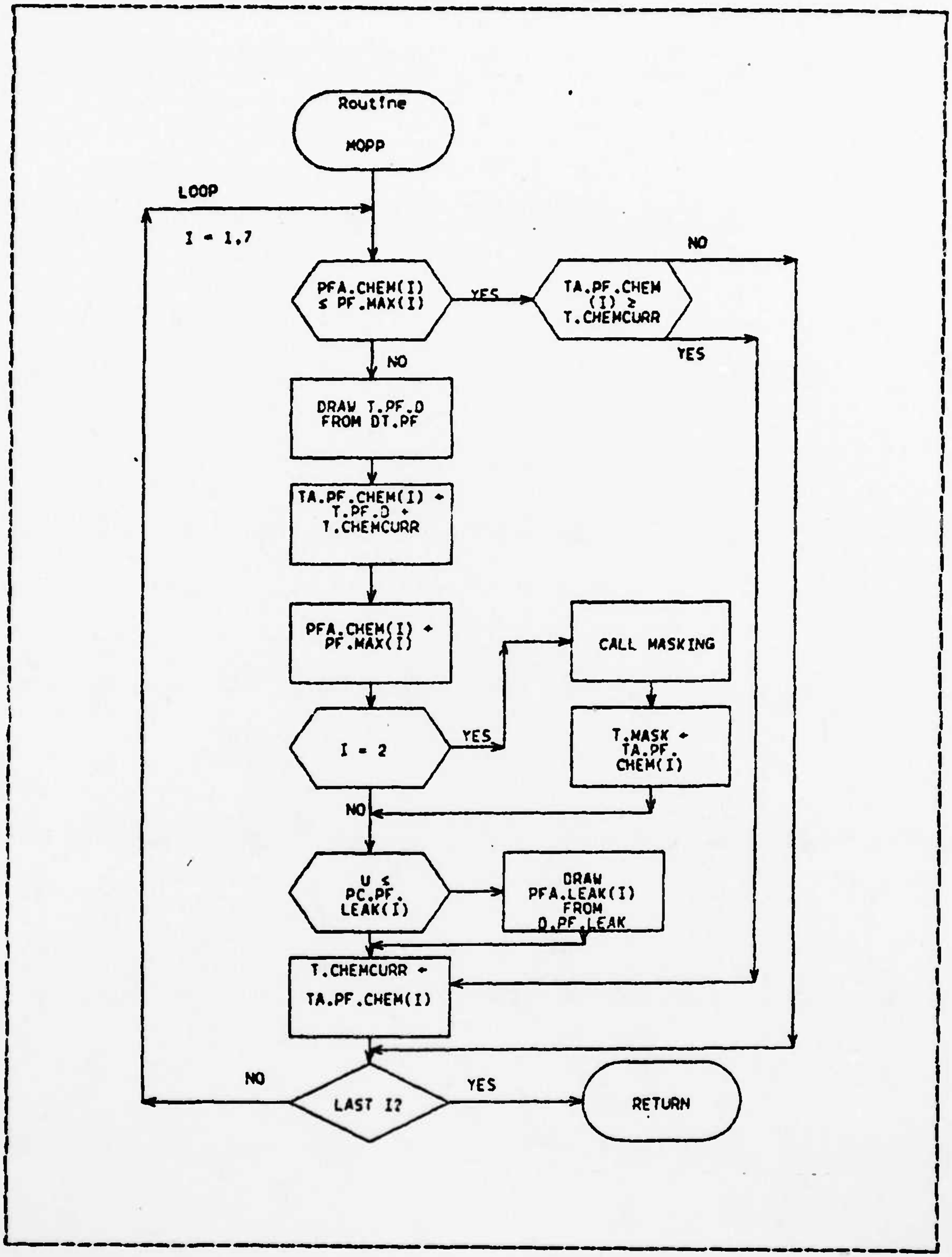

Figure 3.15 Routine MOPP.

be complete, TA.PF.CHEM(i), updates the current time for that PERSON's activities, T.CHEMCURR, and assigns the maximum PF level to the appropriate PF.CHEM attribute.

4. Determines if each item of protective clothing or gear will leak; it it will, assigns a leakage factor to the array PFA.LEAK.

The MOPP routine is called when the PERSON suspects that he has encountered a persistent chemical hazard, and will increase his level of protection to the maximum level of chemical protection specified for his side in the global variable PF.MAX(i) (i=1,...,7). The current level of protection for each body area 1 through 7 is contained in the array TA.PF.CHEM, whose pointer is stored in the attribute PF.CHEM. This level of protection may currently be worn (that is, the time that level was assumed is in the past) or scheduled to be worn (the PERSON is in the midst of chemical actions, and is, or shortly will be, donning items of chemical protection per order, thus the time at which the item is on the PERSON, TA.PF.CHEM(i), is in the future).

If the PERSON is currently wearing an item of full chemical protection (e.g., the protective mask, which will protect body area 2), then the routine checks to see if the donning of this item has been completed or is scheduled to be completed at some time after the individual's current simulation time, T.CHEMCURR. If the item has already been donned, then the routine will loop to the next body area in numerical order (which is also the logical donning order, by design). If the item is scheduled to be donned, then this scheduling is worked into the current schedule by assigning T.CHEMCURR the time at which that scheduled action will be completed, before moving on to the next body area. As a result, even if only part of the body was scheduled to be

protected by previous orders, those scheduled times will be worked into the current scheduling sequence, and the routine will still schedule times for the remaining insufficiently protected body areas. If all items of the body have been protected, the routine will return to the calling routine. Note that T.CHEMCURR has been updated in cases where the individual has been scheduled, but has not yet completed, donning full protection.

For each area of the body which has not yet been afforded full protection, the routine enters the array DT.PF to obtain the appropriate distribution from which to draw the time it took to don that particular item of protective clothing. DT.PF is a 4-dimensional array, ordered by system type (VEH.SYS.TYPE), dimension one; by weapon type (VEH.WPN.TYPE), dimension two; the seven body areas, dimension three; and the distribution type with two parameters, the fourth dimension. Use of the system and weapon type distinguishes between the two sides, and allows different values to be assigned to the distributions depending upon the job of the individual - a crew member on an M1 tank may take longer to don full protection than an infantryman in the open, for example.

If an item of protective clothing has been donned at this time, the routine will check to see if this item of gear will leak due to tears, combat damage, improper donning or fit, agent trapped under the clothing, etc. It does this by comparing a uniform (0,1) random number to the probability that a given item of full chemical protection over body area i will leak, PFA.LEAK(i). If it will, the amount of leakage, expressed as a percentage of the deposition on the outside of the garment, is drawn from the distribution D.PF.LEAK, an N.SIDE X 7 X 3 distribution (the number of sides by the seven body areas by the distribution type and two parameters), and assigned to the array PFA.LEAK, whose pointer is stored in the attribute PF.LEAK.

If the protective mask was donned (body area 2), in addition to assigning values to TA.PF.CHEM(2), PFA.CHEM(2), and PFA.LEAK(2), the routine will update the values for T.MASK, MASK, and MASKLEAK in a similar manner (for further discussion, see the MASKING routine in this section).

After full chemical protection has been assigned to all seven body areas, and the leakage(if any) has been assessed, the MOPP routine returns to the calling program.

7. <u>The Routine DECON</u>

The routine DECON performs the following tasks:

1. Separates out the case of immediate decontamination after initial detection of the chemical agent hazard from the case of delayed decontamination after the appearance of symptoms of chemical agent poisoning.
2. For immediate decontamination:

a. Determines if decontamination will occur using the parameter PC.IMM.DECON.

b. If decontamination does not occur, checks to see if any body area with less than the maximum level of chemical protection was contaminated. If so, sets a PFA.LEAK value to account for agent trapped under the protective garment.

c. If decontamination does occur, schedules decontamination of the skin first, then clothing second, through calls to routine DECON2. The time required to decontaminate multiple agents on the skin, if applicable, is added to the time required to decontaminate one agent using a multiplier AG.MULT.DECON.

3. For delayed decontamination:

a. Schedules decontamination of all body areas through calls to DECON2.

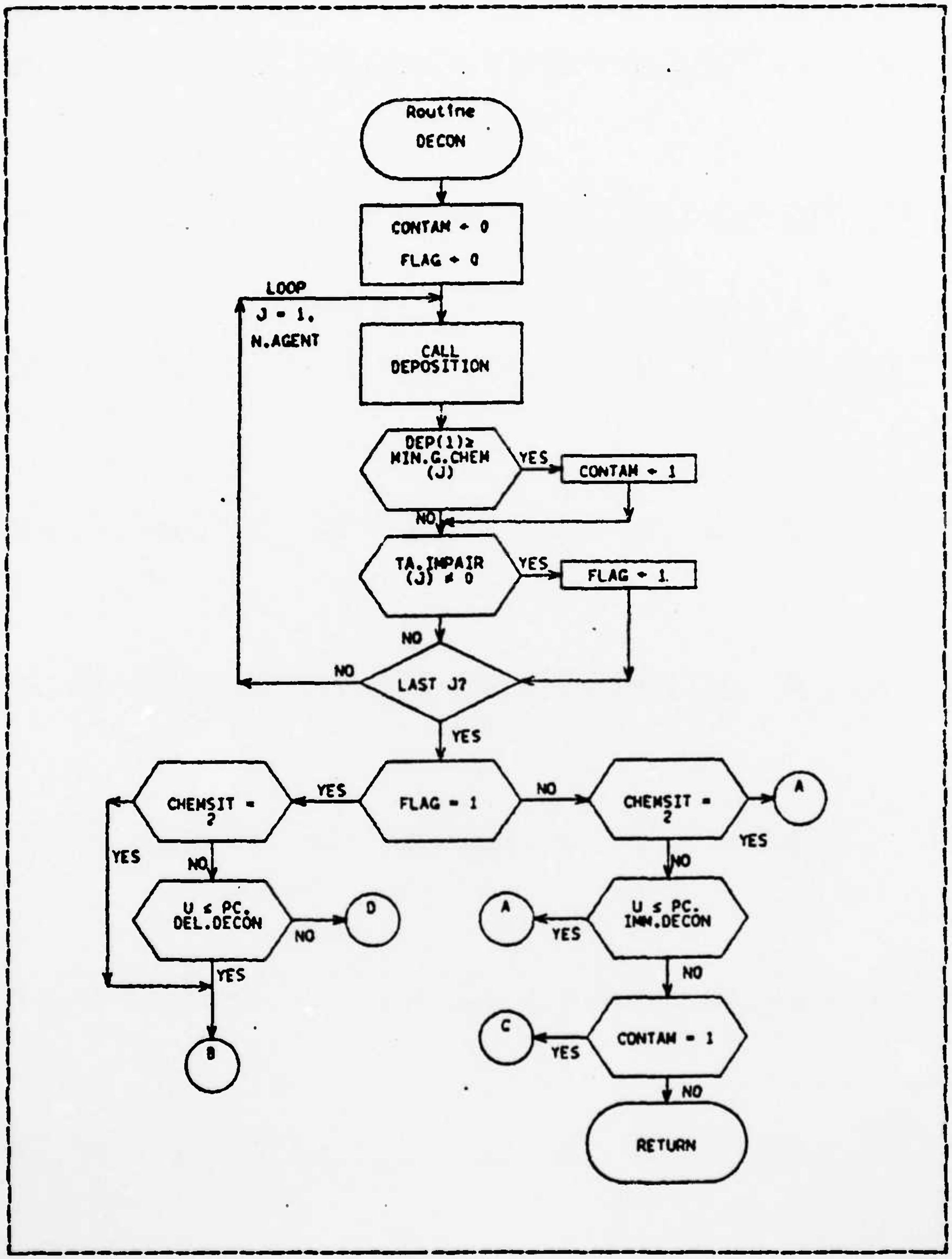

Figure 3.16   Routine DECON.

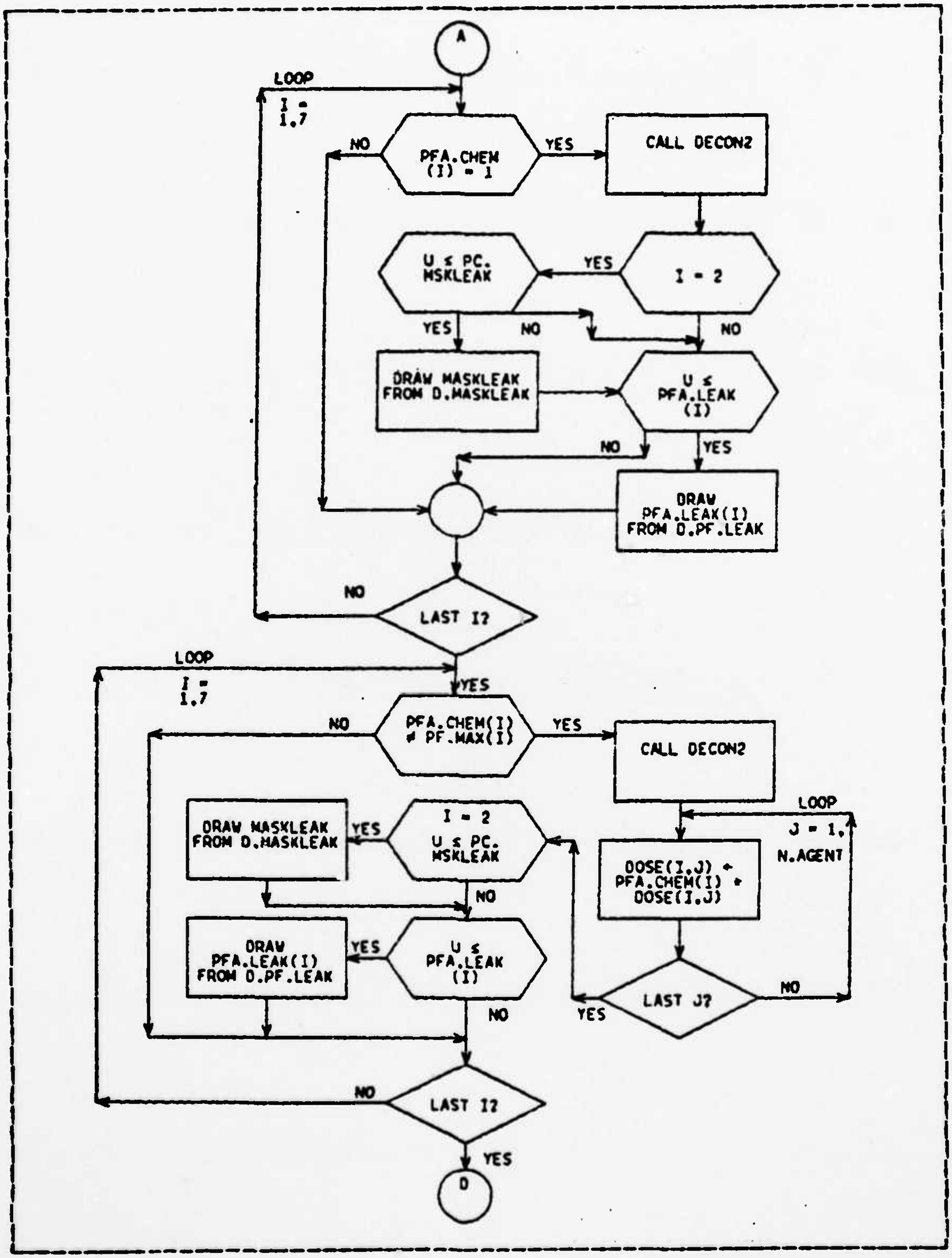

Figure 3.17 Routine DECON, Continuation A.

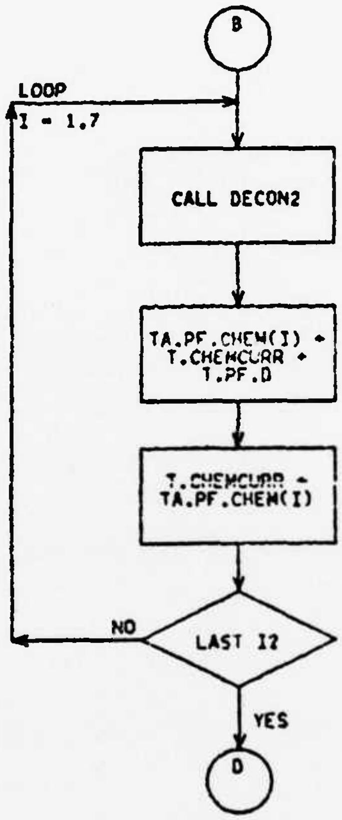

Figure 3.18 Routine DECON, Continuation B.

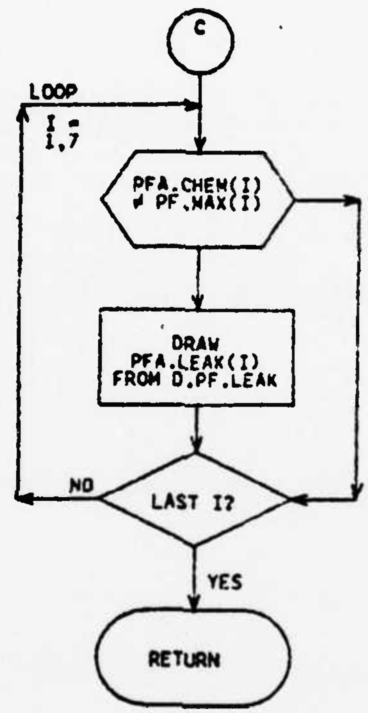

Figure 3.19 Routine DECON, Continuation C.

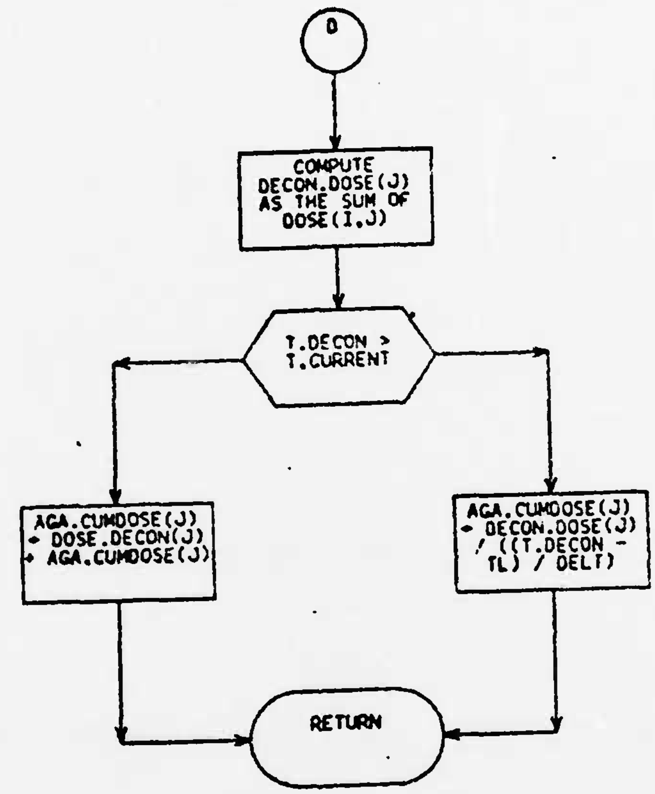

Figure 3.20 Routine DECON, Continuation D.

b. Adds the time required to remove items of protective clothing before decontaminating by doubling the donning time.

4. Determines if the protective mask will leak using the parameter PC.MSKLEAK. If it will, sets a value on the attribute MASKLEAK.
5. Calculates the total dose received during decontamination for each body area by calling the routine DECON2, then summing across all body areas to give the total dosage for each agent.
6. If the decontamination period extends beyond T.CURRENT, then the average dose that would be received during each DELT period from the current time (T.CHEMCURR) until the time decontamination is complete (T.DECON) and assigns this average DELT dose to the array AGA.DECON.DOSE whose pointer is stored in the attribute AG.DECON.DOSE.

The DECON routine is designed to simulate the decontamination of any areas of the body that are not covered by full chemical protection at the time that the chemical agent is detected, or all areas of the body in the event that decontamination is performed at the time that symptoms become apparent.

It is assumed that there are three times when decontamination might be performed. The first is immediately prior to donning full chemical protection after the detection of a chemical hazard. If the individual suspects that the hazard was posed by a persistent or semi-persistent chemical agent (vice a nonpersistent agent), and that some agent may have landed on the body, he will decontaminate those areas not covered by full protection. This implicitly assumes that the person will decontaminate clothing as well as skin not covered by a chemical protective garment, prior to donning the garment. This assumption is justified by

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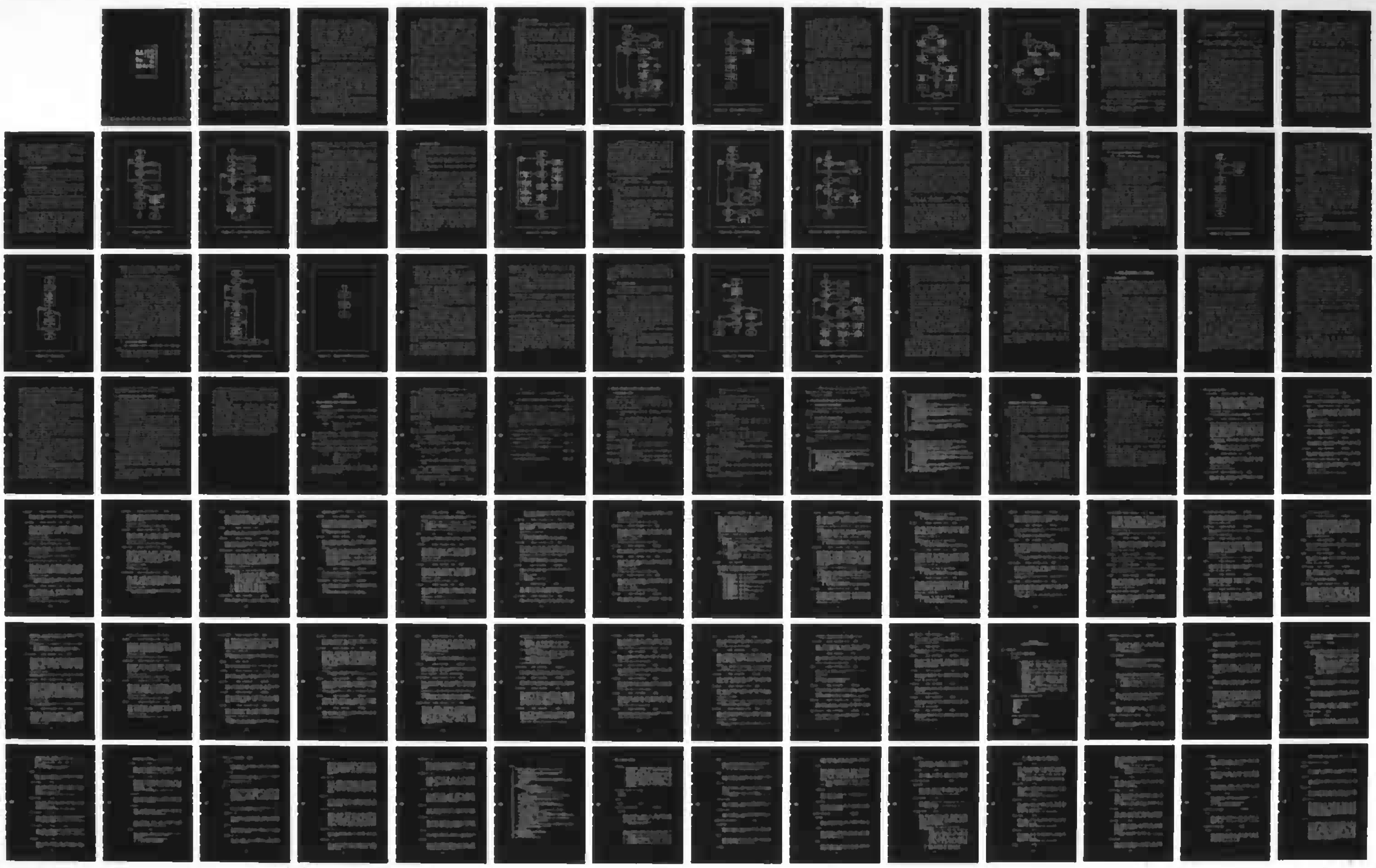


1.0
1.1
1.25
1.4
1.6
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2.0
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2.8
3.2
3.6
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

examining the alternatives presented to the individual : if he dons the garment without decontaminating exposed clothing, the effect will likely be worse than if he delayed donning until decontamination could be accomplished, since he would trap agent under the garment and contaminate the inside of the protective garment.

The second time that a person might decontaminate is when he has detected the appearance of symptoms. If he is not in full chemical protection, these symptoms will probably induce him to assume contamination and react accordingly, depending on the agent involved. Similarly, even if he is in full protection, the appearance of symptoms may induce the removal of the protection, hasty decontamination, and renewal of the protection.

The decision node between the two circumstances is the attribute T.IMPAIR. If T.IMPAIR is not equal to zero for the agent concerned, then symptoms have appeared; otherwise, they have not.

The third time that decontamination may be required is when crossing an area of contamination without full chemical protection. When a person discovers that he has been traversing an area contaminated with a persistent chemical agent, he will decontaminate all exposed areas and don full protection. The probabilities are bypassed in this case since it is assumed that decontamination will occur.

The deposition on the PERSON is assumed to be the linearly interpolated value between his old deposition DEP.G.OLD and his current deposition DEP.G.CURR. This is found by calling the routine DEPOSITION with both the start and end times equal to the current simulation time T.CHEMCURR.

If the PERSON has not shown symptoms, the probability of his assuming that the agent is persistent and that he is contaminated is expressed in the global variable

PC.IMM.DECON. If he chooses not to decontaminate, then a check is made to see if he was, in fact, contaminated. If he was, then the values in the array PFA.LEAK (whose pointer is stored in the attribute PF.LEAK) are assigned positive values in all cases where his current protection factor for body area i (PFA.CHEM(i)) is not the protection factor belonging to the maximum chemical protection (PF.MAX(i)), reflecting the fact that he will have agent trapped under his protective garments when he chooses to don them. If he does choose to decontaminate, then he will do so for all areas of the body not currently fully protected.

The exposed skin is decontaminated first. This is accomplished by calling the routine DECON2. All areas that were not exposed skin (PF = 1) or fully protected (PF = PF.MAX) are decontaminated next through a call to routine DECON2.

For each area not fully protected, a time to both decontaminate and don the appropriate protective item is determined based on the N.SIDE X N.AGENT X 7 X 3 array DT.DECON. The first dimension indicates the side of the PERSON; the second dimension indicates the agent; the third, the area of the body; and the fourth, the distribution type and up to two parameters. The time to accomplish the decontamination of that body area and don the item of protective clothing, T.DECON.D, is added to T.CHEMCURR is computed through a call to the routine DECON2. DECON2 serves as a subroutine to actually compute the decontamination times and dosages received during that time for each area of the body for all agents present on the skin.

If the situation involved delayed decontamination, then the sequence above is followed, except all body areas are decontaminated regardless of the level of protection at the time decontamination is performed. The times to decon and don the protective garment are doubled to reflect the time to remove the old protective item and decontaminate it.

After each decontaminated area is covered, a leakage factor, if any, must be determined. The probability that a given protective item will leak due to inadequate decontamination, improper donning, tears, combat damage, etc are reflected in a global array PC.PF.LEAK. The variable PC.PF.LEAK(i) is compared to a uniform random number to determine if the protective garment covering skin area i will leak. If it will, then the amount that it will leak, PFA.LEAK(i), expressed as a percentage of the deposition on the exterior of the protective item, is drawn from a distribution determined by the 7 X 3 array D.PF.LEAK. The first dimension indicates the body area concerned; the second indicates the distribution type and up to two parameters.

This leakage factor for the mask is determined in the same manner as for the protective areas of the body, using the probability that it will leak, PC.MSKLEAK and the array containing the distribution, D.MSKLEAK. The significant difference between the two is that the MASKLEAK attribute reflects the leakage of agent found in the air into the respiratory system, causing an inhalation dose; the PFA.LEAK array values reflect the leakage of skin protection over various areas of the body, causing an absorption dose.

Because the decontamination process is likely to stretch out over many iterations of CHEM.CHECK, and because the dosage received during the time that decontamination is in process is a function of the decontamination rate (the array DCR), the dosage received during the time of decontamination is computed by calling the routine DECON2. The reasoning behind this calculation and the process of determining the dose is found in Appendix A.

8. The Routine DECON2

The routine DECON2 performs the following tasks for each body area:

1. Determines how many agents are present on the skin and clothing at the time of decontamination. The routine draws the time to decontaminate the first agent T.DECON.D from the array DT.DECON. If multiple agents are present, it will repeatedly multiply MULT.AG.DECON * T.DECON.D.
2. Computes the dosage received during decontamination for each agent present. In the case of crossing a contaminated area on foot where the PERSON remains standing prior to decontaminating, the dose is computed only over areas 5, 6, and 7 (these are the only areas assumed contaminated - see Section B at the beginning of this chapter).
3. Schedules the donning of protective gear and assigns values to the array TA.PF.CHEM, whose pointer is stored in the attribute T.PF.CHEM.

The routine DECON2 is called from the routine DECON for each area of the body not fully protected, so the following explanation refers to each area separately.

The first check performed by the routine DECON2 is to see if there are multiple agents causing contamination (or any - it is possible for a person to suspect contamination where none is present). For the first agent, a time to both decontaminate the body area concerned is determined based on the N.SIDE X N.AGENT X 7 X 3 array DT.DECON. The first dimension indicates the side of the PERSON; the second, the agent concerned; the third dimension indexes the area of the body; and the fourth, the distribution type and up to two parameters. The time to accomplish the decontamination of that body area, T.DECON.D, is added to T.CHEMCURR, the current simulation time.

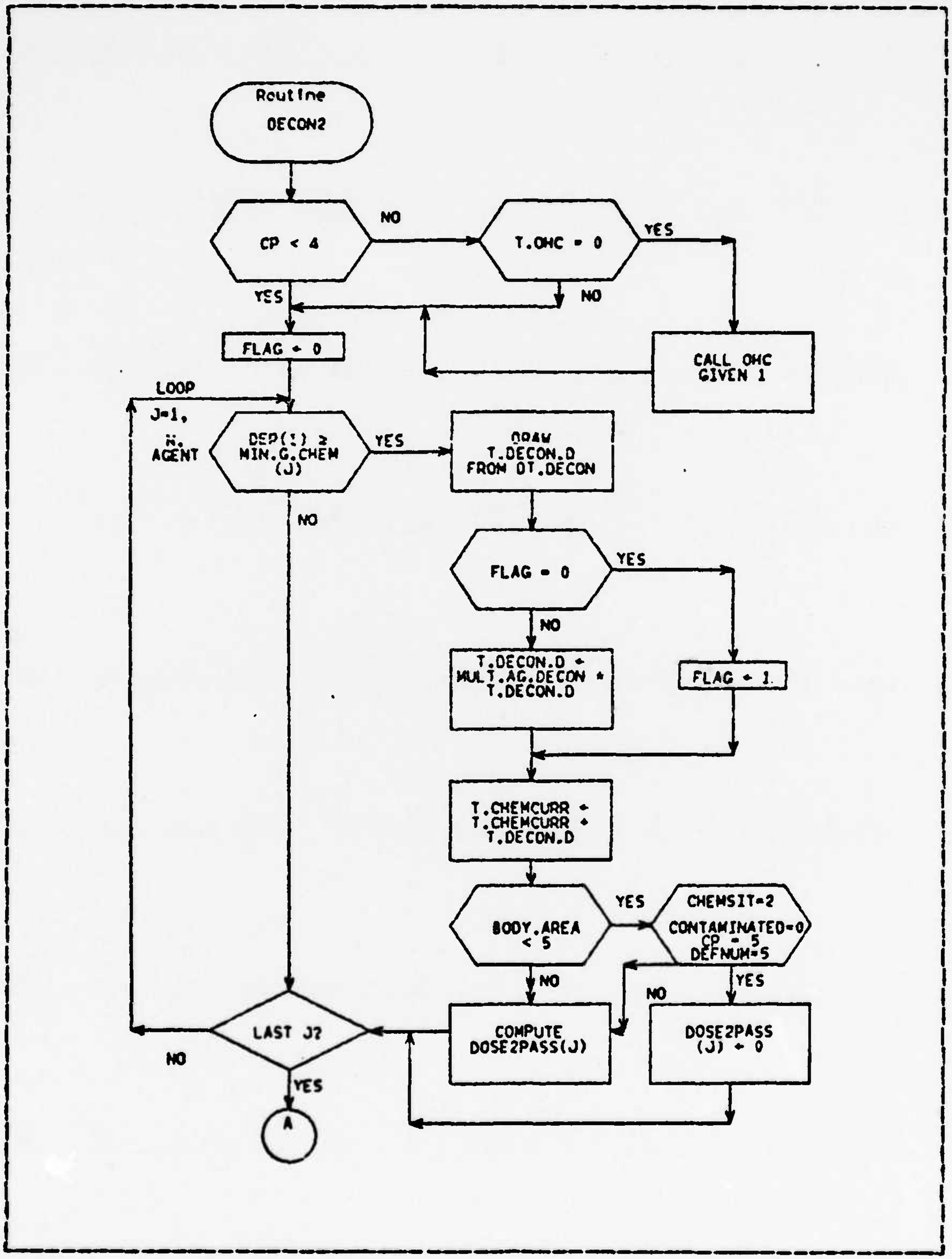

Figure 3.21 Routine DECON2.

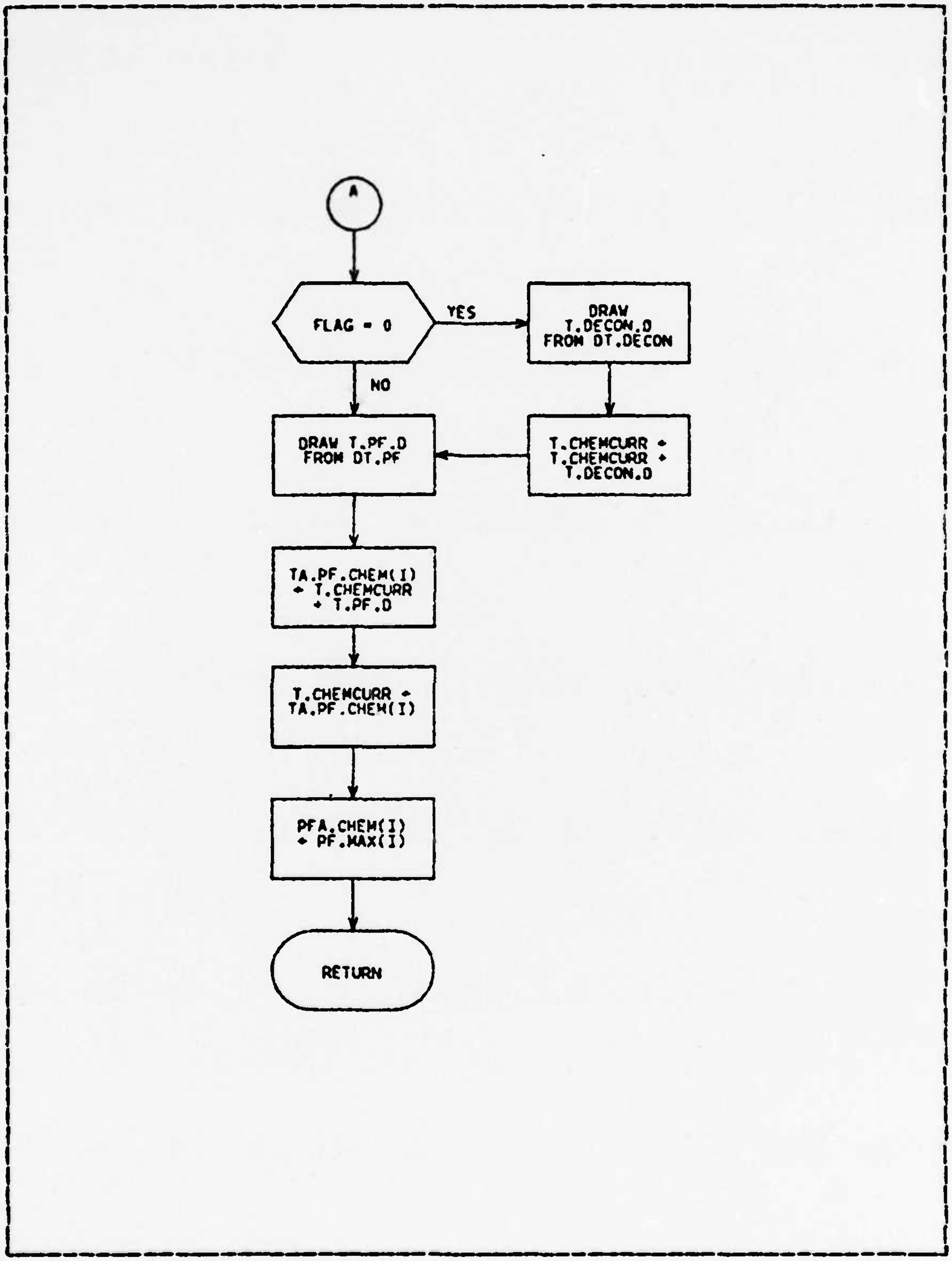

Figure 3.22 Routine DECON2, Continuation A.

If the body area is less than 5 and we are in the situation where the PERSON has been crossing a contaminated area (CHEMSIT = 2) on foot (CP = 5) is not contaminated (CONTAMINATED = 0), and has remained up until decontamination was begun (DEFNUM = 5), then no dosage is assessed. Otherwise, the dosage accumulated during the decontamination of that body area for each agent is computed using the methods outlined in Appendix A. The marginal dose for the body area provided as an argument to the routine for each agent is stored in a temporary variable DOSE2PASS, which is passed between the routines as an argument.

If decontamination was directed (called by the routine DECON) but there was no contamination present (FLAG = 0), decontamination is still performed and T.CHEMCURR is updated by a value T.DECON.D drawn from the distribution DT.DECON.

After a body area has been decontaminated it is covered by a chemical protective garment with a protection factor value equal to PF.MAX (in other words, full chemical protection is assumed). To simulate this, a value T.PF.D representing the time it takes to don the standard item of protective gear for the body area concerned is drawn from the distribution DT.PF (for details on this array, see the section on the routine MOPP in this section). This value is added to T.CHEMCURR to yield the time that the protection was donned, TA.PF.CHEM(i) (i = the body area) and then T.CHEMCURR is updated to this latest time. The level of protection for each item is changed to the level of full protection PF.MAX, as each item is donned.

9. The Routine DEPOSITION

The DEPOSITION routine accomplishes the following tasks:

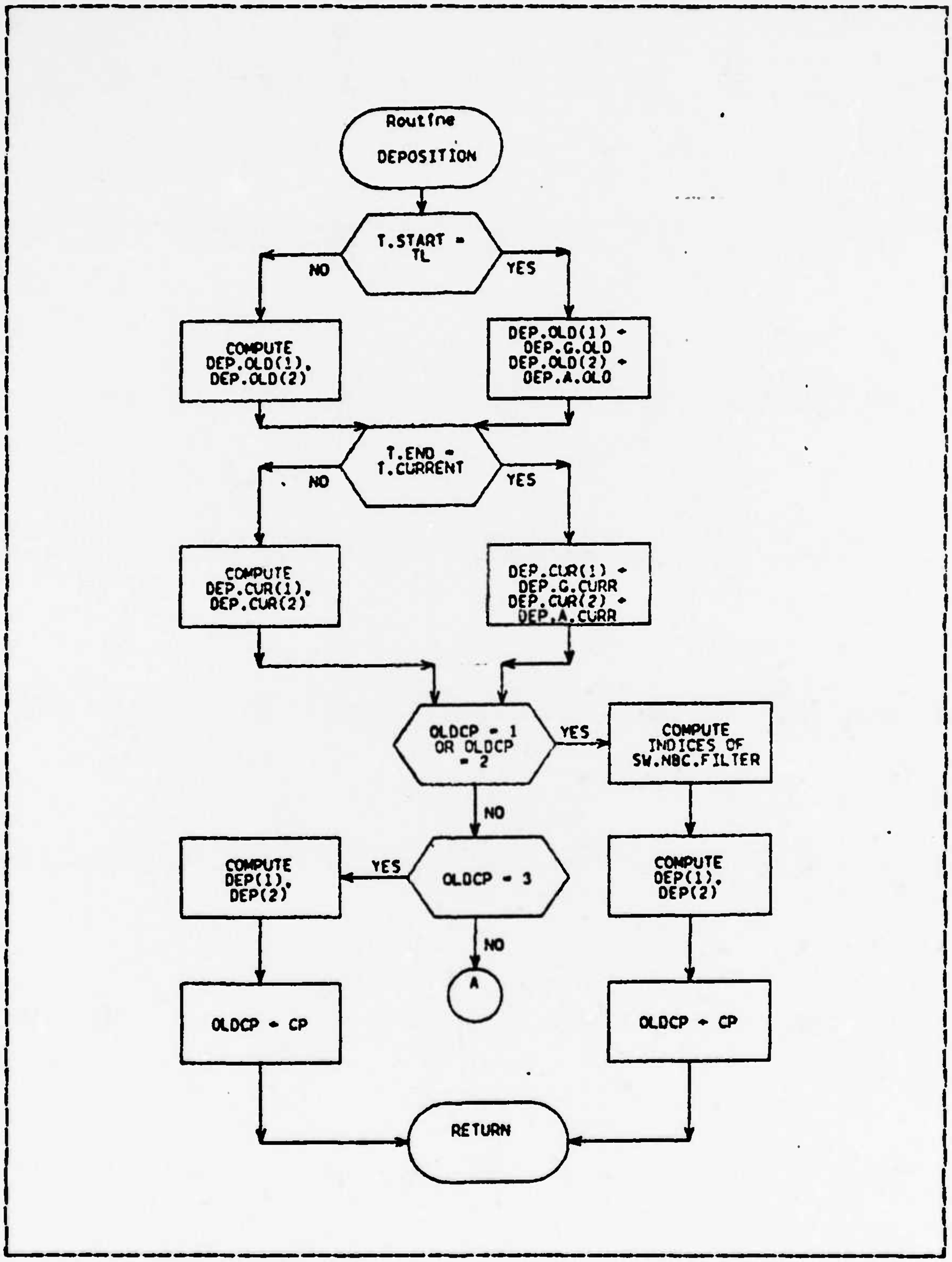

Figure 3.23 Routine DEPOSITION.

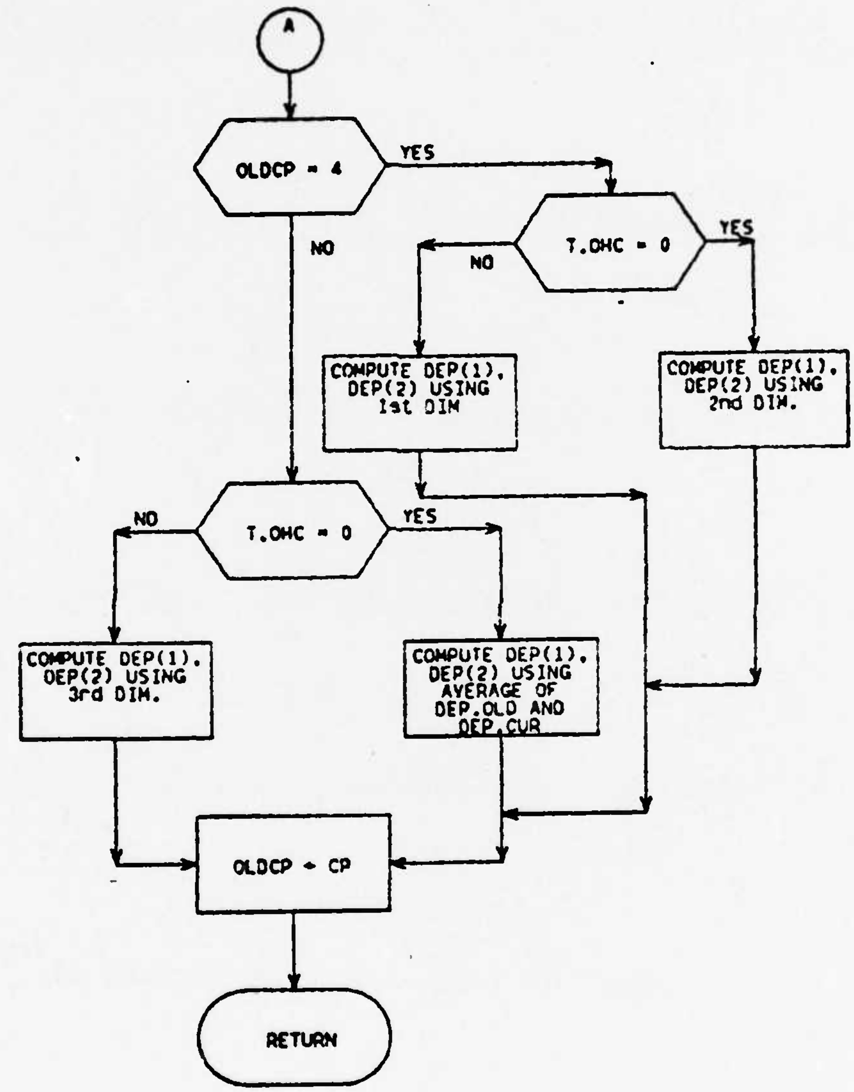

Figure 3.24 Routine DEPOSITION, Continuation A.

1. It computes the ground and air dosage at the given location of interest at any intermediate time within DELT using a linear approximation.
2. It adjusts the deposition received on the ground at the PERSON's location to the dosage received on the outer layer of the PERSON's clothing or skin based on the collective protection category, and the presence of overhead cover.

The DEPOSITION routine may be called by the DOSE2 routine with arguments providing the start time T.START, and the ending time, T.END, which provide the interval of time over which the deposition must be computed. The first action the routine does is to distinguish between the cases so it can come up with an approximate ground deposition at an intermediate time between TL and T.CURRENT if necessary. The previous deposition (time TL) at the PERSON's previous location, calculated the last time CHEM.CHECK was called, is stored in the array DEP.G.OLD for each agent. The current deposition at the PERSON's location (at time T.CURRENT) is stored in the array DEP.G.CURR. A simple straight line interpolation is used to estimate the deposition at an intermediate value. This intermediate value is an approximation over time or both time and space if the PERSON moved during DELT. The formulas used are given below for an agent J:

1. Finding the starting deposition and concentration when the starting time argument (T.START) is not the starting time of the iteration (TL):

DEP.OLD(1) = (DEP.G.CURR(J) - DEP.G.OLD(J)) * ((T.START - TL) / DELT) + DEP.G.OLD(J) (eqn 3.4)

DEP.OLD(2) = (DEP.A.CURR(J) - DEP.A.OLD(J)) * ((T.START - TL) / DELT) + DEP.A.OLD(J) (eqn 3.5)

2. Finding the final deposition and concentration when the final time argument (T.END) is not the ending time of the iteration (T.CURRENT):

DEP.CUR(1) = { (DEP.G.CURR(J) - DEP.OLD(1)) * ((T.END - T.START) / (T.CURRENT - T.START) } + DEP.OLD(1)

(eqn 3.6)

DEP.CUR(2) = { (DEP.A.CURR(J) - DEP.OLD(2)) * ((T.END - T.START) / (T.CURRENT - T.START) } + DEP.OLD(2)

(eqn 3.7)

The deposition used to compute the dosage is simply the average of the depositions for the interval called in the arguments to the routine, as adjusted by the collective protection category (CP).

The routine next checks the collective protection category of the person by checking the global variable OLDCP. If the CP category is changed at any time during DELT, the old CP value is stored in this variable. The deposition routine will be called twice by DOSE2, since there was a change in CP category. As a result, during the first call by DOSE2, when the routine is calculating the dose from the last update time TL to the time the CP category was changed, it will use the original CP category (OLDCP) to determine the appropriate deposition adjustment required. It will set the value of OLDCP to the newer CP value after doing this, so that the next time DEPOSITION is called by DOSE2, the newer CP value will be used. If the CP value had not changed during DELT, the UPDATE routine, called before DEPOSITION, will have set the value of OLDCP to the current CP value, contained in the PERSON's CP attribute.

If the OLDCP value is one or two, the PERSON is inside a vehicle. The adjustment factors for vehicles are contained in a six-dimensional array SW.NBC.FILTER, which is

dimensioned number of system types by number of weapon types by 2 categories of PERSON (crew or passenger) by 3 categories of vehicles (closed with overpressure, closed without overpressure, and open) by 2 agent states (vapor/aerosol or liquid) by the number of agents. The value contained in the array indicates the percentage of the outside dosage of agent that will penetrate into the vehicle. This value is multiplied by the average dosage over the interval of interest to yield the deposition used in dosage calculations.

If the OLDCP is three, the person is in a bunker. The array DEP.RED is used to calculate the reduction in deposition afforded by the bunker. The global array DEP.RED is dimensioned N.AGENT X 3 X 2, with the different agent types, 3 categories of protection (bunker, CP = 3; foxhole CP = 4, with no overhead cover; and in the open CP = 5, with overhead cover) and 2 agent states (vapor/aerosol and liquid). The value again represents the percent of the unadjusted ground deposition will penetrate into the collective protection.

If the OLDCP is four (foxhole), a check is made to determine if the foxhole has temporary overhead cover (T.OHC not equal to zero, indicating the overhead cover has been assumed). If it has, it is assumed to provide the same degree of chemical protection as a bunker, and the dose is computed accordingly. If not, a different value from DEP.RED is multiplied by the average ground deposition to give the deposition on the PERSON.

If the OLDCP is not one, two, three, or four, it must be five (or in error), which indicates that the PERSON is in the open. A check is made to see if temporary overhead cover has been assumed (T.OHC not equal to zero). If it has, the third index in the second dimension of DEP.RED is used to find the amount of agent that has penetrated under the

cover. If no cover has been assumed, no adjustment is made to the deposition - the deposition on the ground at the PERSON's location is assumed to be the same as that found on the PERSON, and the average of the old and current depositions is used to find the dosage received.

In each case, the OLDCP value is assigned the new CP value after the deposition has been calculated, and control returns to the calling routine.

10. The Routine DOSE1

The routine DOSE1 accomplishes the following tasks:

1. It determines if there is any chemical agent present at the PERSON's location, either on the ground (and thus, on the PERSON if exposed) or in the air. If not, the routine exits to the calling program.
2. The routine computes the dose received during the previous DELT period of time, if not already computed. It does this by either computing the dose in the routine, or by calling the DOSE2 routine.

The initial check provides a means of bypassing this routine in cases where the individual is not in an area of chemical hazard or contaminated as of the current time, T.CURRENT. If he is facing either a ground or airborne hazard, the routine must compute the dose received from that hazard.

The routine first checks to see if decontamination was being performed in the DELT interval of interest, and has not yet been completed. If it was, the dose for the interval has been computed by the DECON routine, and the dose to be accumulated during DELT is stored in the array AGA.DECON.DOSE, whose pointer is stored in the attribute AG.DECON.DOSE (see routine DECON). The DOSE1 routine will update the accumulated dose by adding the amount in

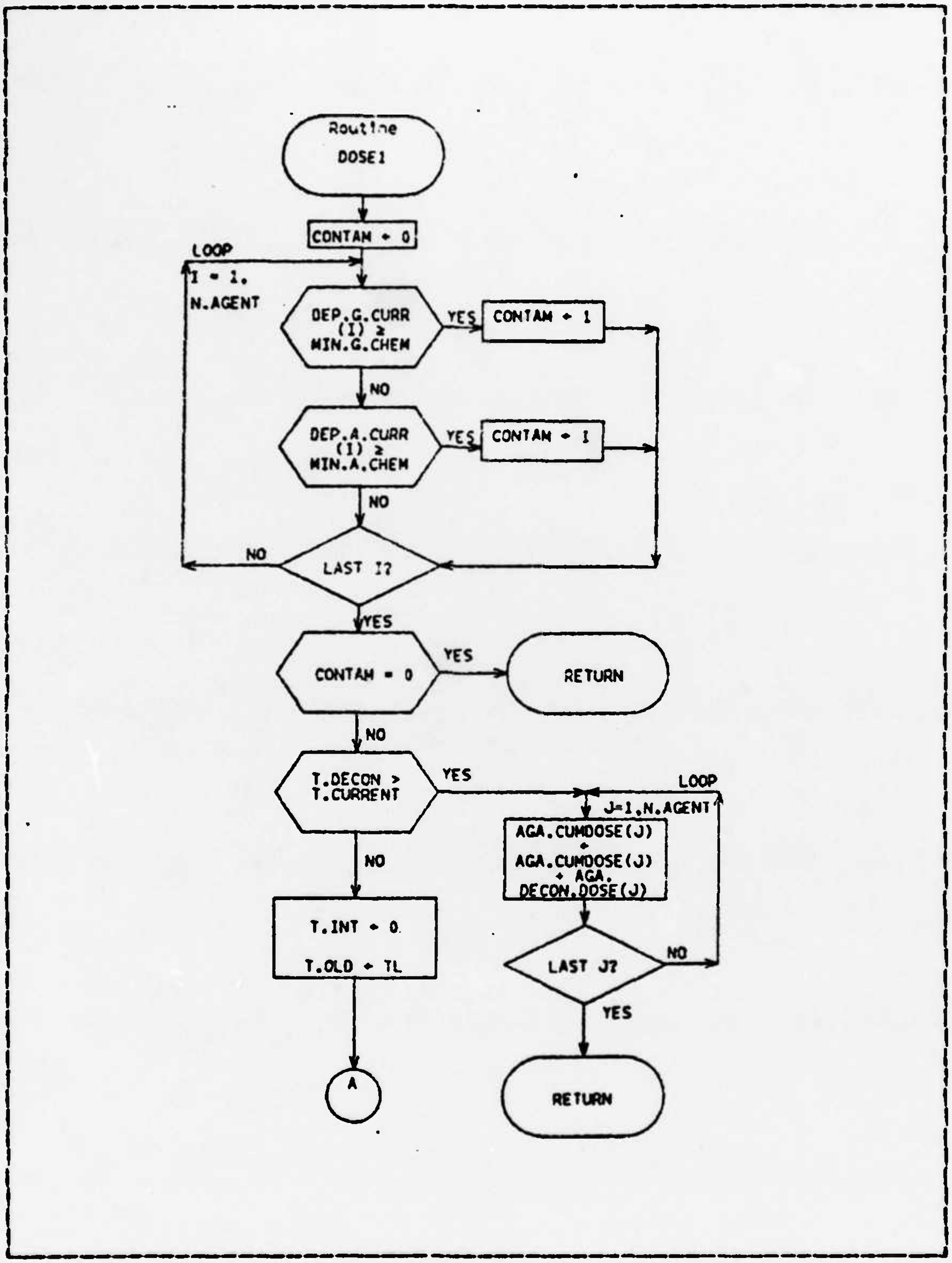

Figure 3.25 Routine DOSE1.

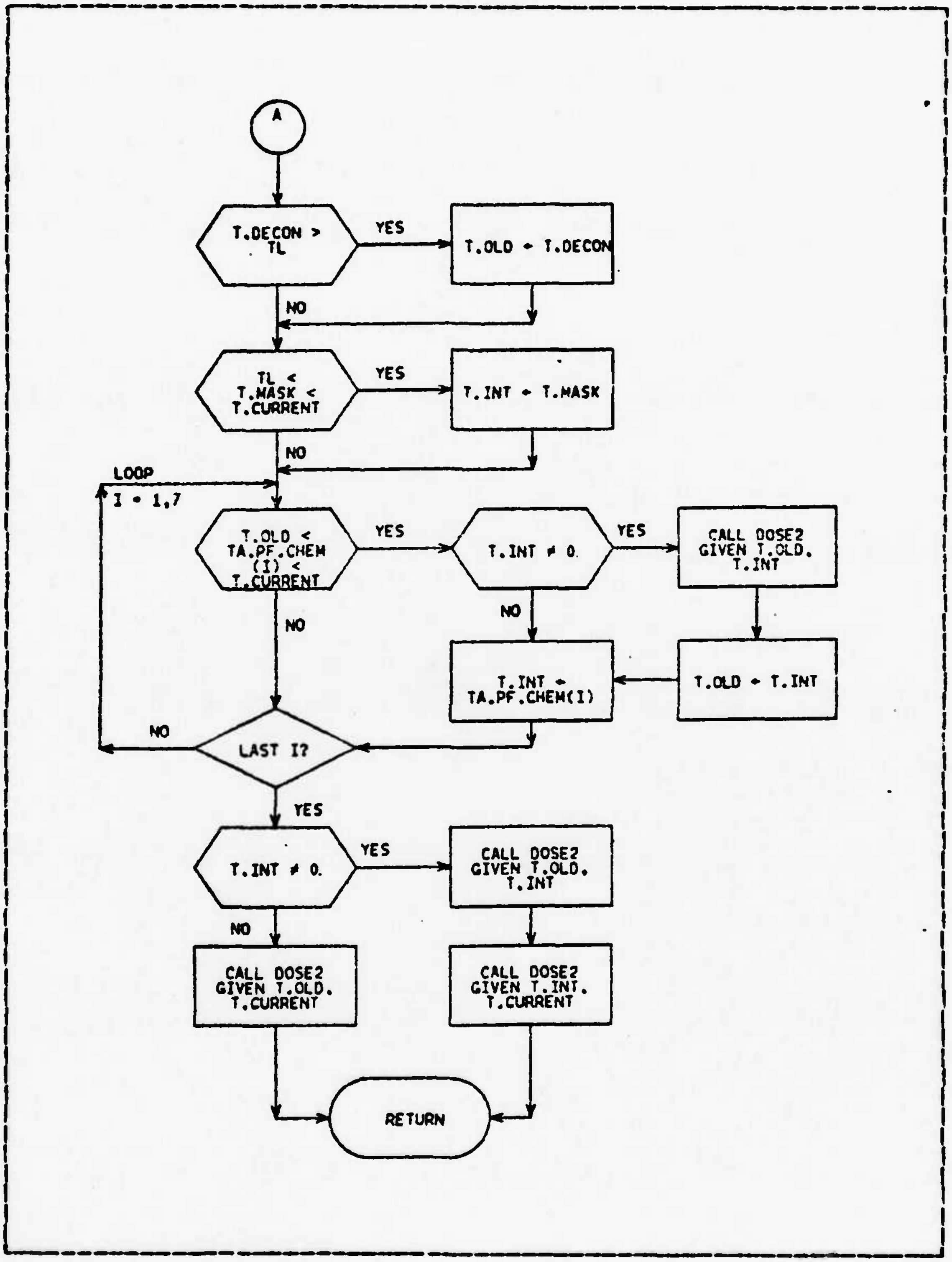

Figure 3.26 Routine DOSE1, Continuation A.

AGA.DECON.DOSE to the value contained in the array AGA.CUMDOSE for each agent. Control is then returned to the calling program.

If decontamination had been completed during the last DELT seconds, the routine will compute the dose since decontamination was completed, by setting the beginning of the interval over which the dose is to be computed, T.OLD, to the time decontamination was completed, T.DECON.

The program next checks to see if masking or donning of any individual items occurred during the DELT period of interest. If masking or donning an item had been completed during the DELT period, dosage calculations are performed at the old level of protection until the new level was completely assumed, then at the new level of protection. For example, if the mask had been donned during DELT and the attribute T.MASK was five seconds after the start of the interval, then the routine would compute the dosage received without a mask for five seconds, and with a mask worn for the remaining (DELT - 5) seconds. If there had been a completion during that time, the T.MASK or TA.PF.CHEM(i) (i=1,...,7) completion value would be assigned to the temporary variable T.INT, which is used as an argument for the DOSE2 routine. Checks are made to see if two or more events occurred during DELT; if they have, the dosage is computed over each interval separately.

The routine next calls the DOSE2 routine, which actually computes the dosage received during appropriate interval and assigns the cumulative dose to the array AGA.CUMDOSE for each agent. Both inhalation and percutaneous dosages are considered, and converted to an equivalent intravenous (IV) dose.

11. The Routine DOSE2

The DOSE2 routine accomplishes the following task: It computes the dose received during the interval passed to it from the routine DOSE1 under each of the following circumstances:

1. No action was taken during the given interval that would have affected the PERSON's chemical protective status, or
2. The PERSON changed his collective protection status during DELT.

The routine first checks to see if the collective protection category (CP) changed during the interval passed to it (T.START to T.END) from the routine DOSE1. The DEPOSITION routine is called for the interval T.START to T.CP (the time that the collective protection category was changed), then the dosage is computed, the DEPOSITION routine is called again and the remaining dosage computed. Changes in the overhead cover category, indicated by a T.CHC (the time overhead cover was assumed) within the interval, are handled in an identical manner.

If there had been no changes in protection status during the interval, the DEPOSITION routine is called for the entire interval T.START to T.END and the dosage is computed at one time.

The DEPOSITION routine returns the effective deposition on the outer layer of the clothing or protection (if any) over the body. The amount of liquid agent reaching the skin is this deposition value multiplied by the protection factor of the item of clothing, etc. between the skin and that layer of deposited agent. The protection factor for bare skin is, of course, 1.0 (100% of the agent is transmitted to the skin).

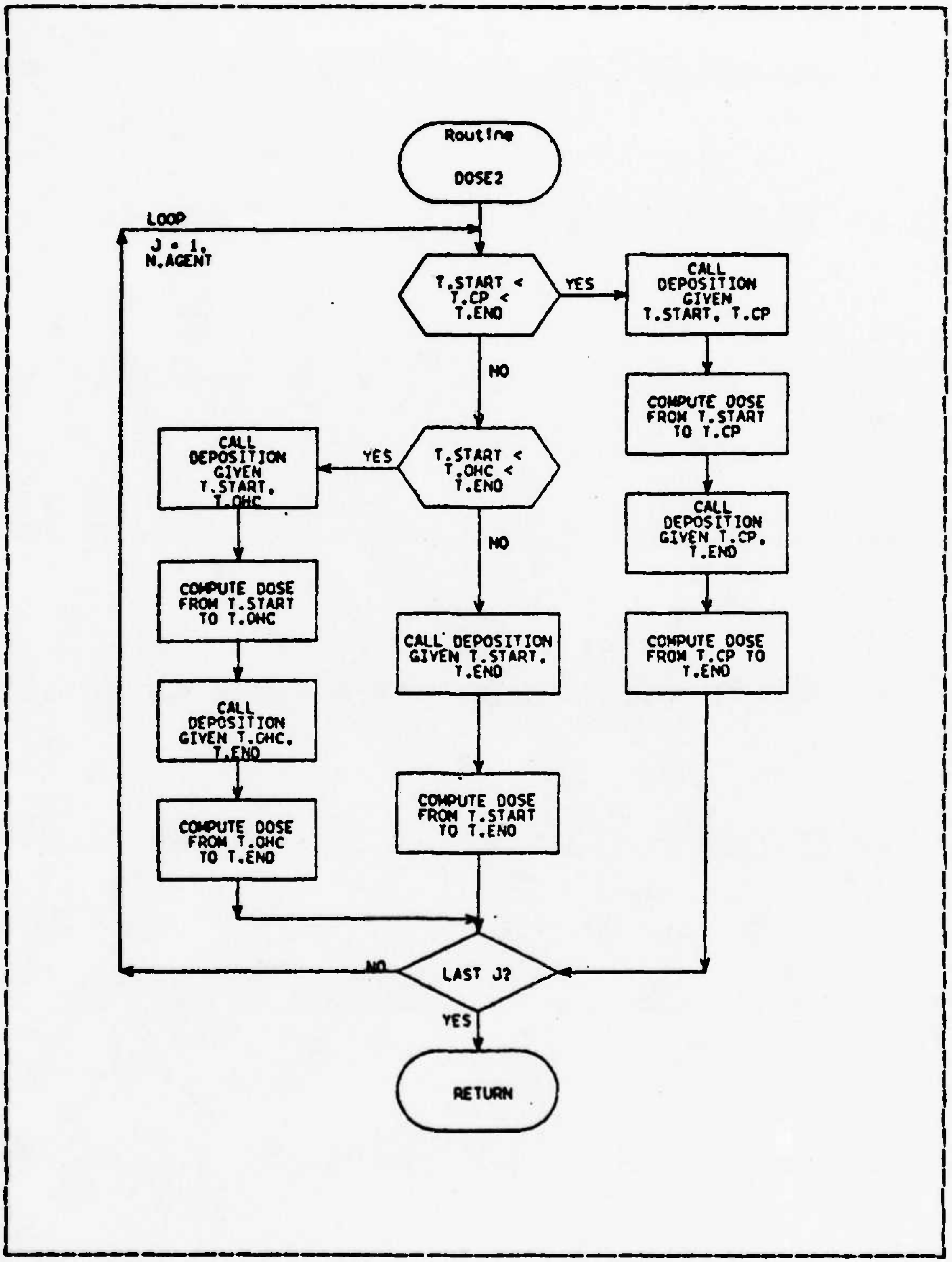

Figure 3.27 Routine DOSE2.

A pressurized vehicle (CP = 1) is the only system that will reduce the amount of vapor/aerosol that reaches the immediate vicinity of the PERSON, so no adjustments are made to the airborne concentration of agent i, found in the array DEF.A.CURR(i). The percutaneous hazard associated with airborne aerosol or vapor agents is assumed negligible, so the only hazard posed by the agent is the inhalation hazard. This can be reduced only by the protective mask, so only the attributes MASK (indicating if the mask is on or off) and MASKLEAK (indicating if the mask leaks) will affect the inhalation dosage received by the individual.

The actual calculation of the dosage received during the interval is explained in Appendix A.

12. <u>The Routine CHEMCAS.EFFECTS</u>

The CHEMCAS.EFFECTS routine accomplishes the following tasks:

1. Simulates the injection of the nerve agent antidote when symptoms of possible chemical agent poisoning appear, when presented with an actual nerve agent hazard, and when detection of any chemical agent hazard occurs.
2. Determines if the impairment dose threshold of the PERSON has been passed for each of the chemical agents, and assigns the time that the threshold has been reached to the array TA.AG.INCAP, whose pointer is stored in the attribute T.AG.INCAP.
3. Calls the routine SYMPTOM.DETECT the first time that an impairment dose threshold is passed.
4. Determines if the incapacitation dose threshold of the PERSON has been passed for each of the chemical agents, and assigns the time that the threshold has been reached to the array TA.AG.INCAP.

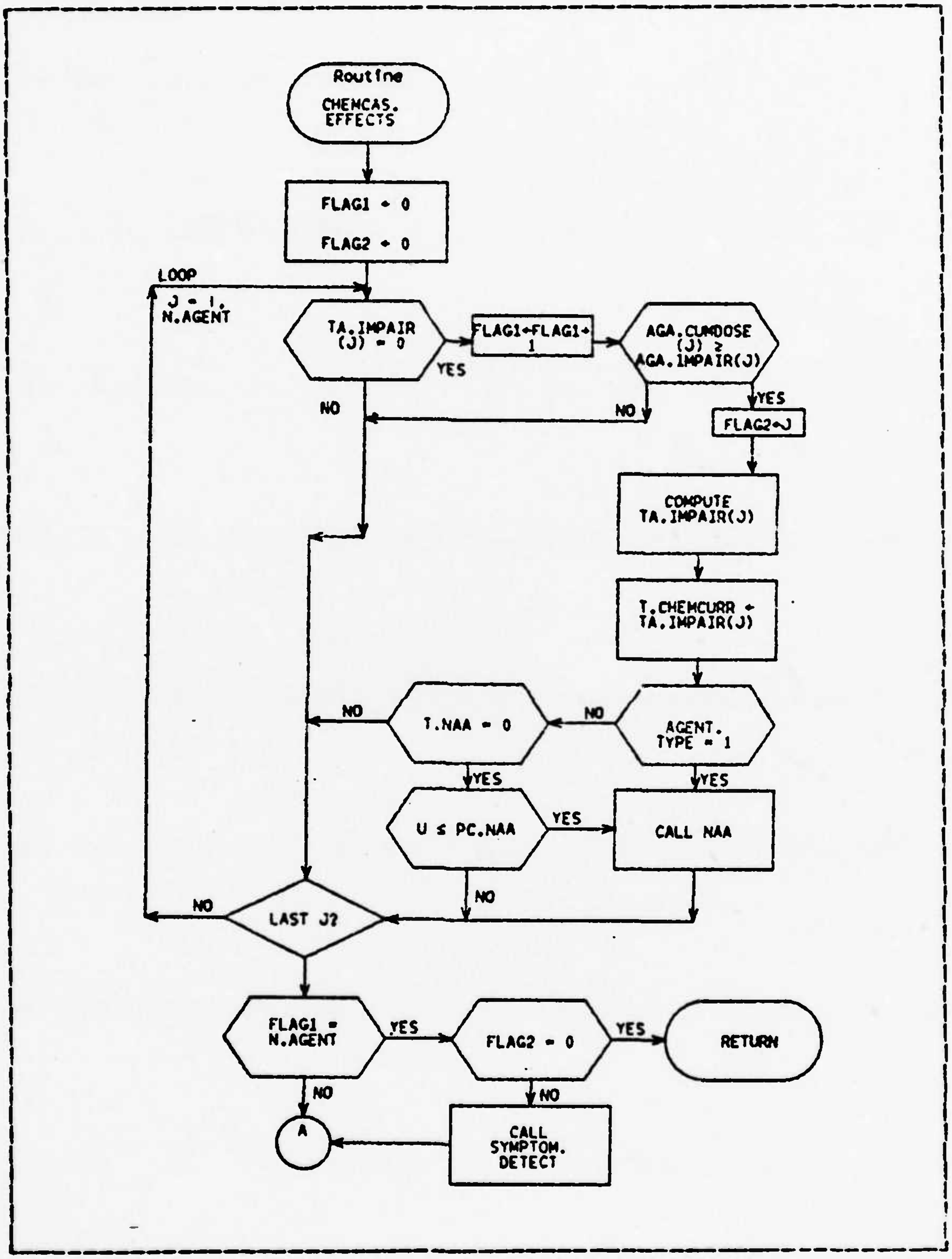

Figure 3.28 Routine CHEMCAS.EFFECTS.

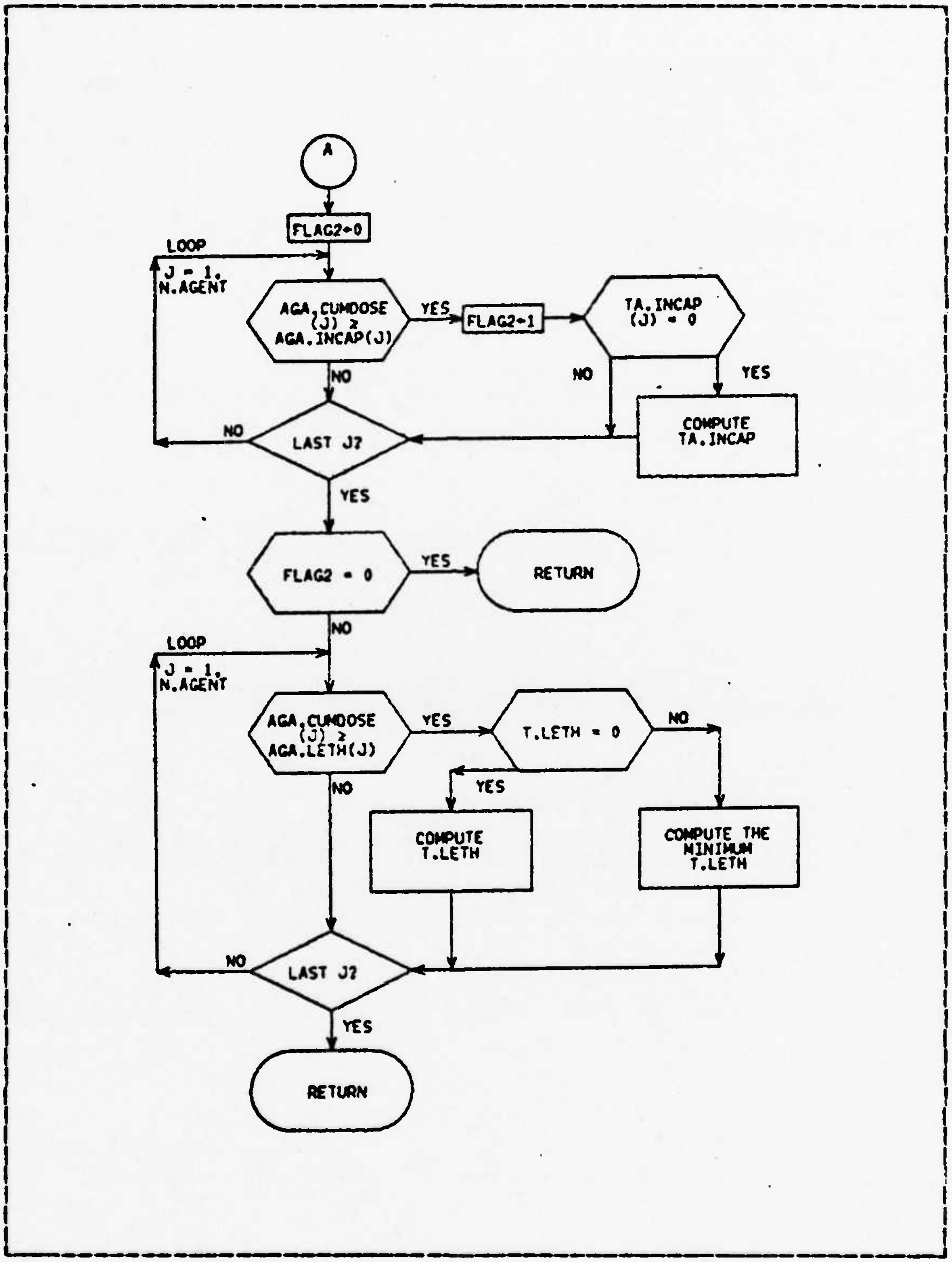

Figure 3.29 Routine CHEMCAS.EFFECTS, Continuation A.

5. Determines if the lethal dose threshold has been passed for any agent. If it has, assigns a time of death through the attribute T.LETH.

The CHEMCAS.EFFECTS routine is designed to translate the accumulation of dosage into physical effects, that is, reaching a level of impairment, incapacitation or death. It also handles the simulation of the possible injection of a nerve agent antidote by the soldier by calling the routine NAA.

The routine begins by checking to see if the impairment dose threshold, found in the array AGA.IMPAIR whose pointer is stored in the attribute AG.IMPAIR, has been reached for any chemical agent. When an impairment dose threshold is reached, a time of impairment is assigned to the array TA.IMPAIR, whose pointer is stored in the attribute T.IMPAIR. This time is computed by a simple linear interpolation shown in equation 3.9. The dose at the end of the last iteration is contained in the array OLD.DOSE, a global variable updated in the routine UPDATE for each PERSON.

$$T.IMPAIR(J) = [(AGA.IMPAIR(J) - OLD.DOSE(J)) / (AGA.CUMDOSE(J) - OLD.DOSE(J))] + TL \qquad \text{(eqn 3.9)}$$

If it has, and an impairment dose had not been reached earlier, the the routine SYMPTOM.DETECT is called to determine if the onset of impairment (causing the appearance of symptoms) will result in the scheduling of a detection (if a chemical hazard has not already been detected). If two or more agents cause impairment during the same DELT interval, the one with the highest number is arbitrarily used to call SYMPTOM.DETECT. The temporary variables FLAG1 and FLAG2 are used to keep track of how many times an impairment dose has been reached, and what agent caused the impairment.

If the agent causing the incapacitation is a nerve agent, then injection of an antidote will be performed. This is accomplished by calling the routine NAA. The possibility of wrongful injection is again considered. If the nerve agent antidote has not previously been administered, then, when symptoms of a chemical agent appear, it is possible that the soldier, as a result of poor training or panic, may inject himself with the nerve agent antidote. This probability of this is contained in the global variable PC.NAA, which is dimensioned as a vector of size equal to the number of sides. Users who wish to eliminate this option may simply set this variable equal to zero. If injection will occur, based on the comparison of a uniform (0,1) random number with PC.NAA, the routine NAA will be called.

The routine next checks to see if the dose has reached the level of incapacitation for each agent. If it has, a time of incapacitation from that agent is assigned through the array TA.AG.INCAP(i) for each agent i, using equation 3.9 substituting INCAP for IMPAIR. Separate array values are maintained for future possible discrimination between different agent effects in multiple agent scenarios in the main model, instead of using the first time of incapacitation as a single attribute.

If the incapacitation dose has been reached for one or more agents, the routine checks to see if the lethal threshold has been reached. If it has, a time of death, T.LETH is assigned as an attribute of the PERSON in the same manner as above. Unlike the case with impairment or incapacitation, the PERSON can be killed only once; future iterations of CHEM.CHECK should not include lethalities.

This routine does not translate the event of impairment, incapacitation, or death into combat effects; this should be done in the main simulation using the times attributed to each PERSON. The ability of the PERSON should

be degraded appropriately for the agent and level of effect, starting at the time a level of effect is reached. Chapter 4 discusses this matter in more detail.

13. The Routine SYMPTOM.DETECT

The routine SYMPTOM.DETECT accomplishes the following tasks:

1. If the PERSON has not yet detected the presence of a chemical hazard, the routine schedules a detection at the impairment time of the first agent to cause impairment. The onset of impairment is assumed to be the time of the first appearance of noticeable symptoms.
2. Regardless of when detection occurred, the routine will call the routines MASK, OHC, DECON, and MOPP in the same manner as other routines call this sequence at the time a chemical agent hazard is detected.

The SYMPTOM.DETECT routine allows the appearance of symptoms to initiate the realization or detection of the presence of a chemical agent hazard, which causes the PERSON to react accordingly. The routine only acts if the PERSON has not already reached an impairment dose for any particular agent. When the first impairment threshold is passed, marking the first onset of symptoms, this routine will be called by the routine CHEMCAS.EFFECTS. It will not be called at any other time. If the person has previously detected the chemical agent, then he has already taken (or is scheduled to take) most protective actions that it is possible for him to take. However, he may have elected not to perform certain things, and hay may wish to perform delayed decontamination. For this reason, the routine is called even if the PERSON has previously detected the presence of a chemical agent hazard.

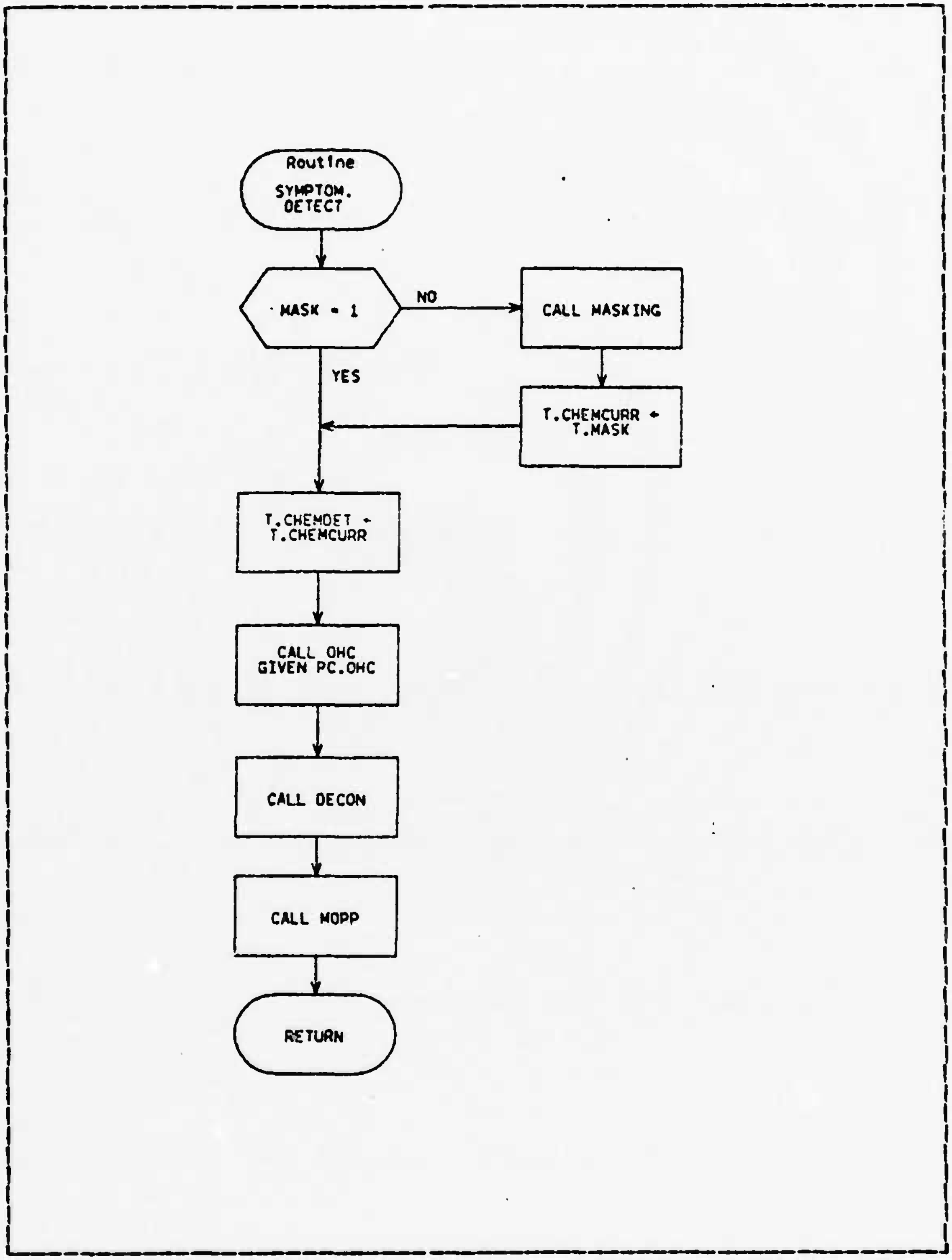

Figure 3.30 Routine SYMPTOM.DETECT.

First, the PERSON will mask, if he is not presently wearing the mask. Note that this will occur regardless of the CP category, unlike before. The reason for this is obvious - any collective protection that might have prevented a person from masking before has evidently failed. If masking was required, the detection time is assigned to the time that the mask was completely donned - as before, the individual will not have detected the agent from the aspect of warning others until the mask has been put on. If he was already masked, then detection is scheduled for the moment that symptoms occurred (the impairment time passed by CHEMCAS.EFFECTS).

In either case, the individual may assume overhead cover, if necessary, so that he may decontaminate any exposed areas of the body. This is done by calling the routine OHC.

The DECON routine will be called, and the probability of delayed decontamination, contained in the global variable PC.DEL.DECON, will be used (the DECON routine is found in this section). This decontamination, if performed, will be over all body areas, to include those previously covered by protective gear (which is removed and replaced or decontaminated). If decontamination is not accomplished (which would result in an increase in individual protection to full protection), the MOPP routine will be called, causing the individual to don all items of chemical protective gear not already worn.

After the MOPP routine is called, the routine will return to CHEMCAS.EFFECTS.

14. <u>The Routine NAA</u>

The NAA routine accomplishes the following tasks:

1. Determines the time of the injection of the nerve agent antidote, and assigns that time to the attribute T.NAA.

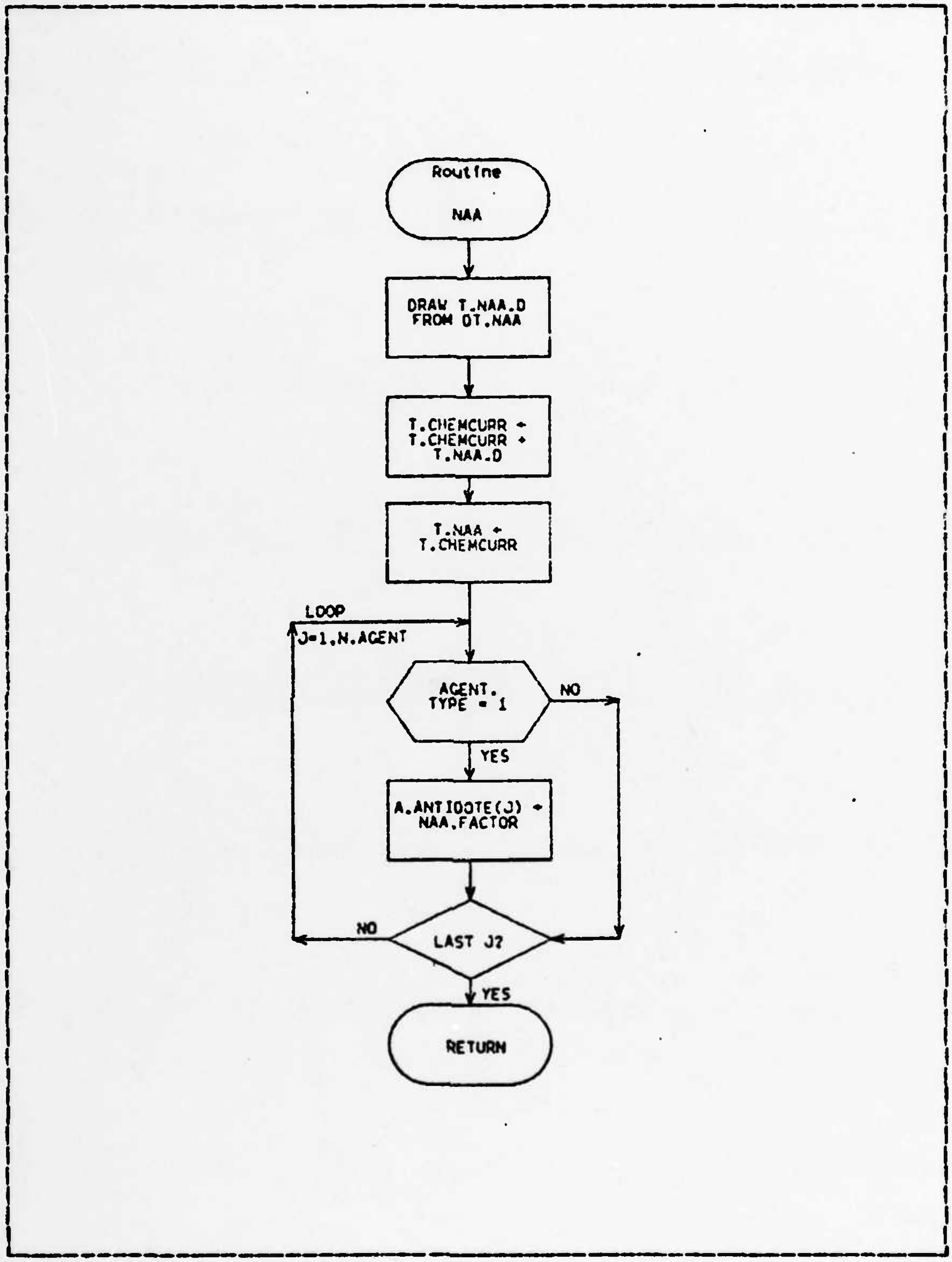

Figure 3.31 Routine NAA.

2. Updates the array A.ANTIDOTE, assigning the value contained in the global variable NAA.FACTOR to the array elements corresponding to nerve agents.

The NAA routine is called whenever an injection of a nerve agent antidote is to be performed. The term nerve agent antidote used here is a generic one referring to the antidote carried by the soldier; this will vary according to his nationality. For the US, the current antidote is atropine. The time it takes to administer the nerve agent antidote is drawn using the array DT.NAA, which is dimensioned N.SIDE (the number of sides) X 3 (the distribution type and two parameters). The result is added to the current simulation time for the individual, T.CHEMCURR. This completion time is also assigned to the attribute T.NAA.

The antidote is assumed to cause a reduction in the effective dosage received by the PERSON, which can be expressed as a percentage of the actual dose absorbed. This percentage is contained in the global variable NAA.FACTOR, which is dimensioned as a vector of size equal to the number of sides or forces modeled. Thus, for nerve agents, the actual cumulative dose is equal to the nominal accumulated dose times the appropriate NAA.FACTOR. Incorporation of this change in the dosage calculations is accomplished through the array A.ANTIDOTE, whose pointer is stored in the attribute ANTIDOTE. The value in the array A.ANTIDOTE is changed from its initial value of 1 to the value NAA.FACTOR for every agent whose type is nerve.

15. <u>The Routine CROSSING</u>

The CROSSING routine accomplishes the following tasks

1. Simulates the protective measures that would be taken by ground troops that encounter a chemical agent contamination hazard while moving.

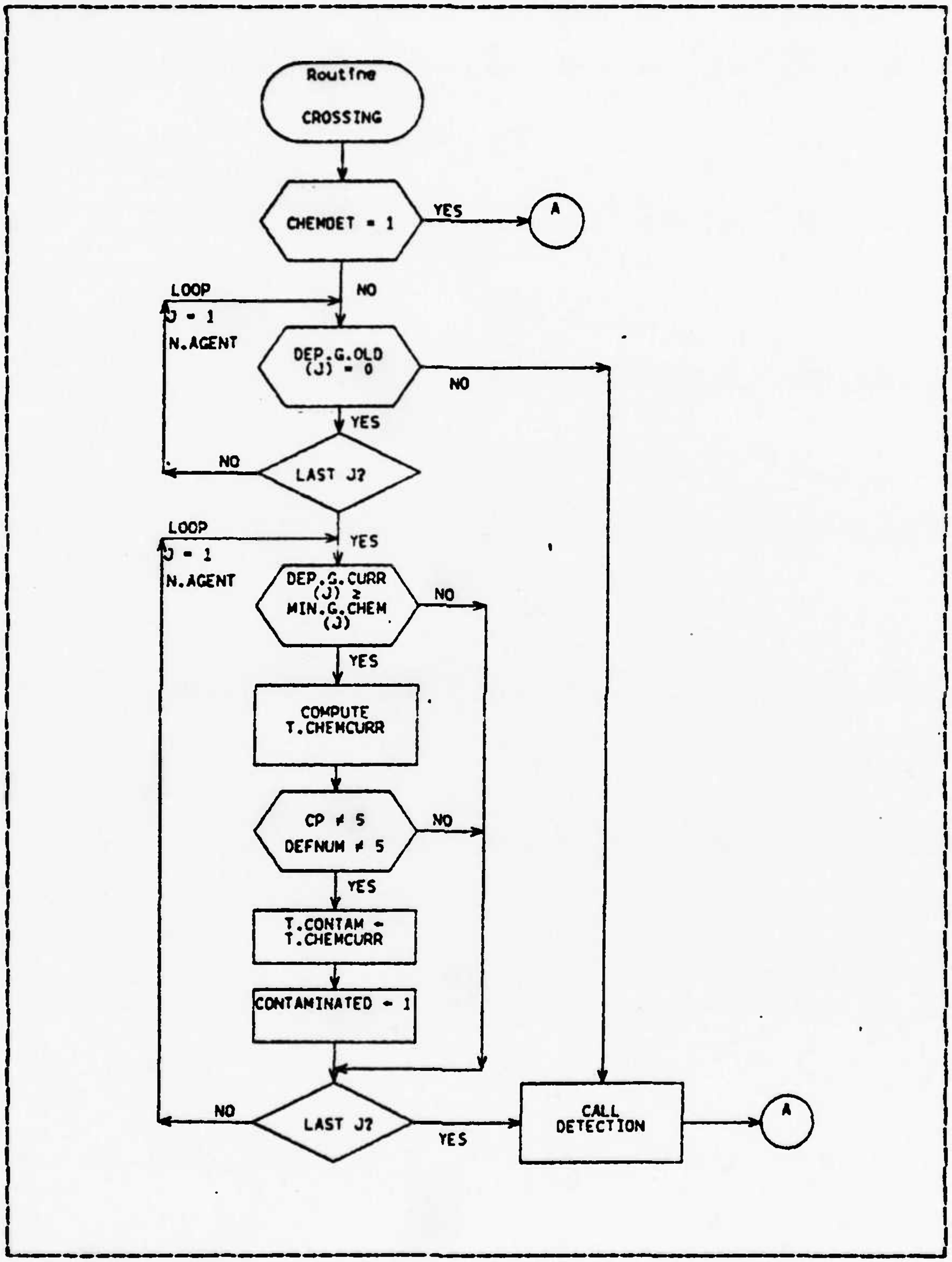

Figure 3.32 Routine CROSSING.

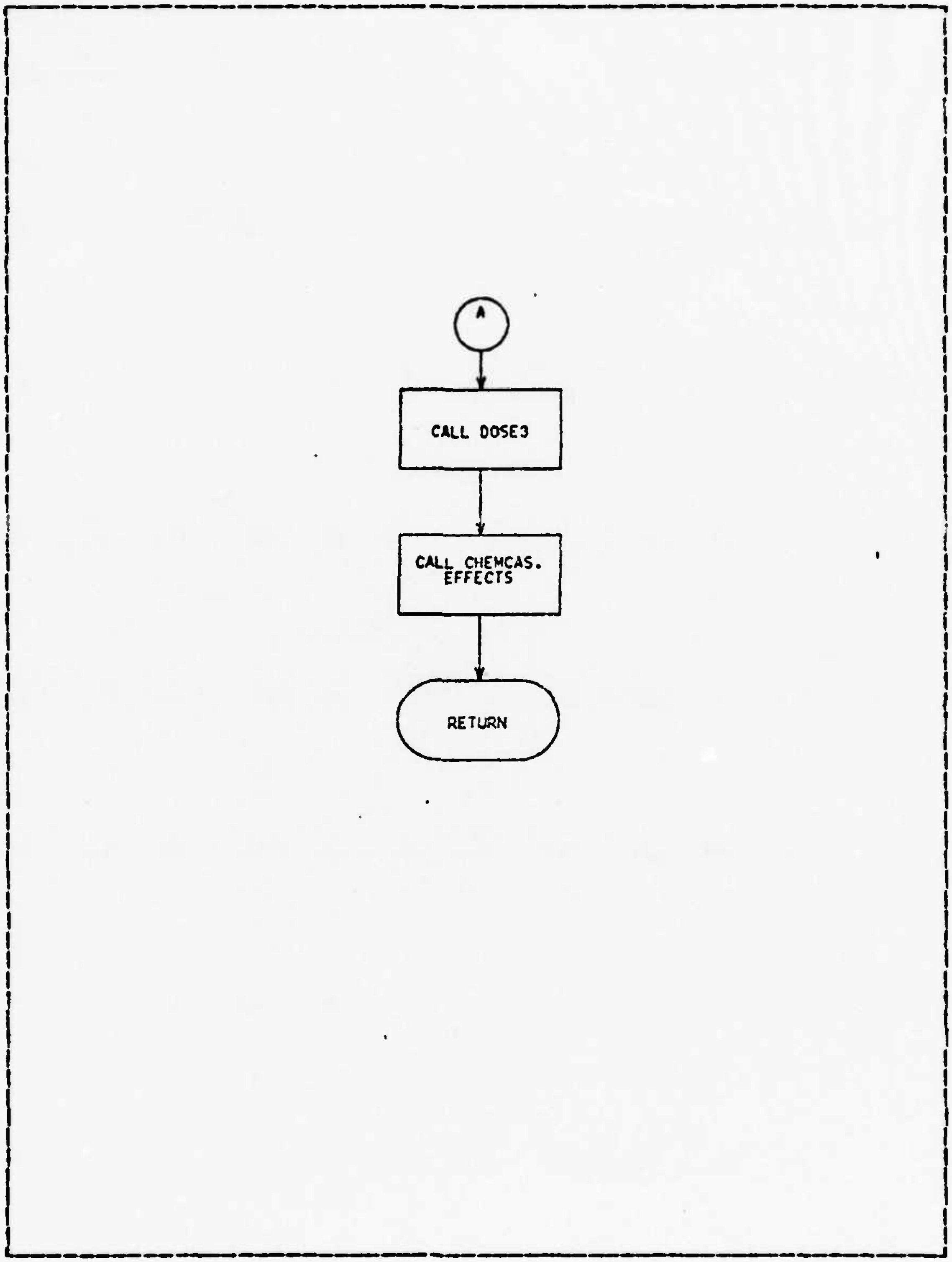

Figure 3.33 Routine CROSSING, Continuation A.

2. Computes the dosage that would be received by troops crossing an area of prior deposition.
3. Handles all calculations in lieu of the routine CHEM.CHECK, once CHEM.CHECK has updated the situation and found that it involves crossing a previously contaminated area (any area with ground deposition but no agent in the air from primary deposition).

The CROSSING routine handles the simulation if the chemical situation, CHEMSIT, is determined to be a case where the PERSON is moving in an area where all chemical agent has fallen onto the ground. The PERSON may be entering an area of chemical agent contamination from a clean area, or he may be moving about in an area of deposition sufficiently long after the delivery system impacted that all agent has fallen to the ground.

The detection, reactive measures, and dosage calculations will be different in cases involving moving over contamination as opposed to being attacked by an agent or encountering a chemical agent cloud. The first check the routine does is to see if CHEMDET is equal to 1, indicating that the PERSON has detected the presence of a chemical agent hazard. If he has, then all reactive measures will have been scheduled through attribute assignments and the routine can call the dosage computation routine directly. For a crossing situation, the dosage routine is DOSE3 (see this section). The casualty effect sequence CHEMCAS.EFFECTS is called next, then the routine returns to the CHEM.CHECK routine.

If the PERSON has not previously detected the presence of a chemical agent hazard, then the routine checks to see if the PERSON was in contamination previously (DEP.G.CLD not equal to zero for any agent). If he had not been, then he must have just entered an area of contamination and the

beginning point for any chemical effects or actions, T.CHEMCURR, must be set at the time at which he first entered the contamination.

It is assumed that the deposition at his previous area was zero (it really could have been just under the significant level). At some point the MIN.G.CHEM threshold was passed en route to the current location. For simplification, it is assumed that the deposition increased linearly. The point on the ground at which the MIN.G.CHEM level was reached is therefore:

(MIN.G.CHEM - 0) / (DEP.G.CURR - 0) * the distance from (OLDX,OLDY) to (X.CURRENT, Y.CURRENT) (eqn 3.10)

A time DELT was required to make the move. For simplification, it is assumed that the move started at the beginning of the interval, time TL. The time at which the MIN.G.CHEM threshold was reached, assuming a constant speed, is therefore:

(MIN.G.CHEM/DEP.G.CURR) * DELT + TL (eqn 3.11)

This value is used to set T.CHEMCURR to indicate the beginning of the chemical crossing situation.

After the beginning of the chemical encounter has been found (it is TL, the last update time if contamination was encountered previously), the routine calls the DETECTION routine in the same manner as is done with CHEM.CHECK; the only difference is that if detection occurs and therefore the DETECTION routine calls the DECON routine, the probability of decontamination in the DECON routine is set at one; when crossing contaminated ground, if the individual is not already in full chemical protection, he will decontaminate.

After calling the DECON routine, the DOSE3 routine is called to compute the dose. The sequence continues by calling the CHEMCAS.EFFECTS routine as before and returning control to CHEM.CHECK, which will return to the main combat simulation (this is the end of the iteration for this PERSON).

16. The Routine DOSE3

The DOSE3 routine computes the accumulated dose for each agent in situations where the PERSON is crossing an area of previous chemical contamination.

The DOSE3 routine is called only by the CROSSING routine; as such, it only computes the dose in cases where the PERSON is in chemical situation two, crossing an area of previous chemical contamination (see the CROSSING routine in this section). The dosage received from crossing a contaminated area will be different from that received when in an area where agent is still falling toward the ground, as the only agent that can affect the individual is agent picked up from contact with the ground. The amount of agent picked up from the ground will depend on the soldier's collective protection, his mission, and the pickup rate for that agent under the current environmental conditions.

Certain assumptions have been made about the pickup of agent while moving. They are:

1. If the CP = 1 (inside a closed vehicle with overpressure), there will be no effective contamination, and the dose will be that computed through a leakage rate specified in the array SW.NBC.BREATHING. This is done in the DOSE2 routine.
2. If the CP = 2 (vehicle not equipped with overpressure), there will again be no direct contamination assumed and the dosage received will depend on different leakage rates found in SW.NBC.BREATHING, computed in DOSE2.

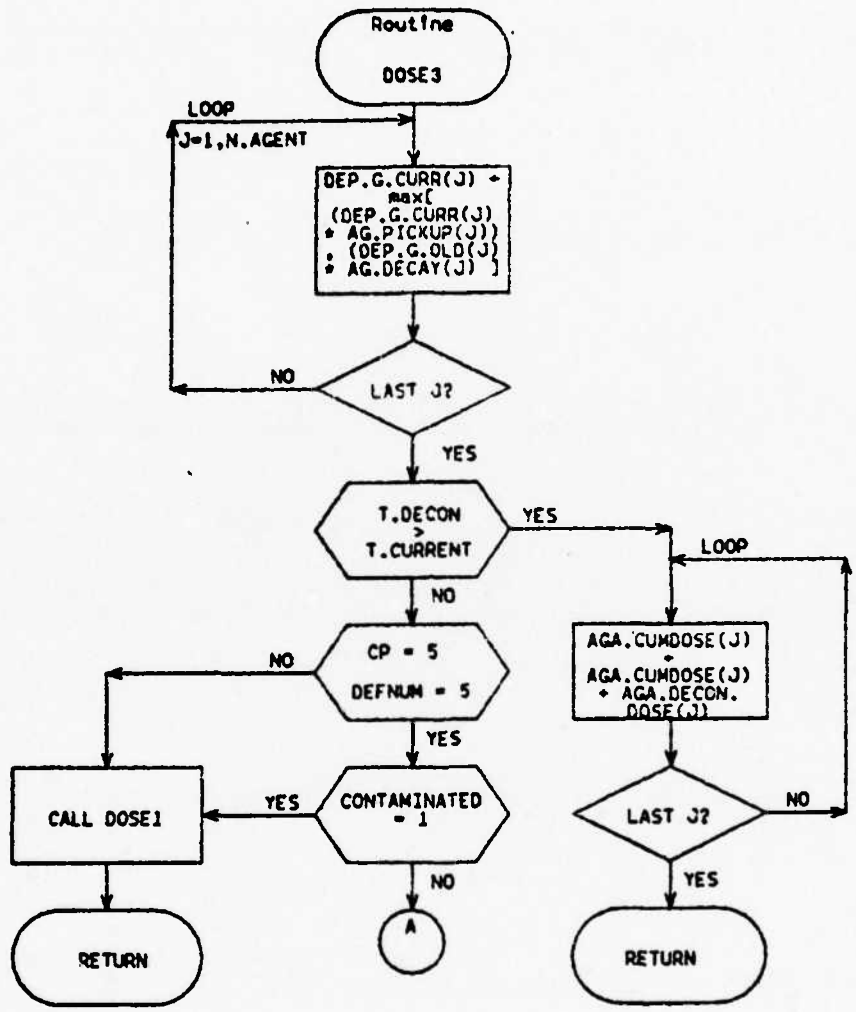

Figure 3.34 Routine DOSE3.

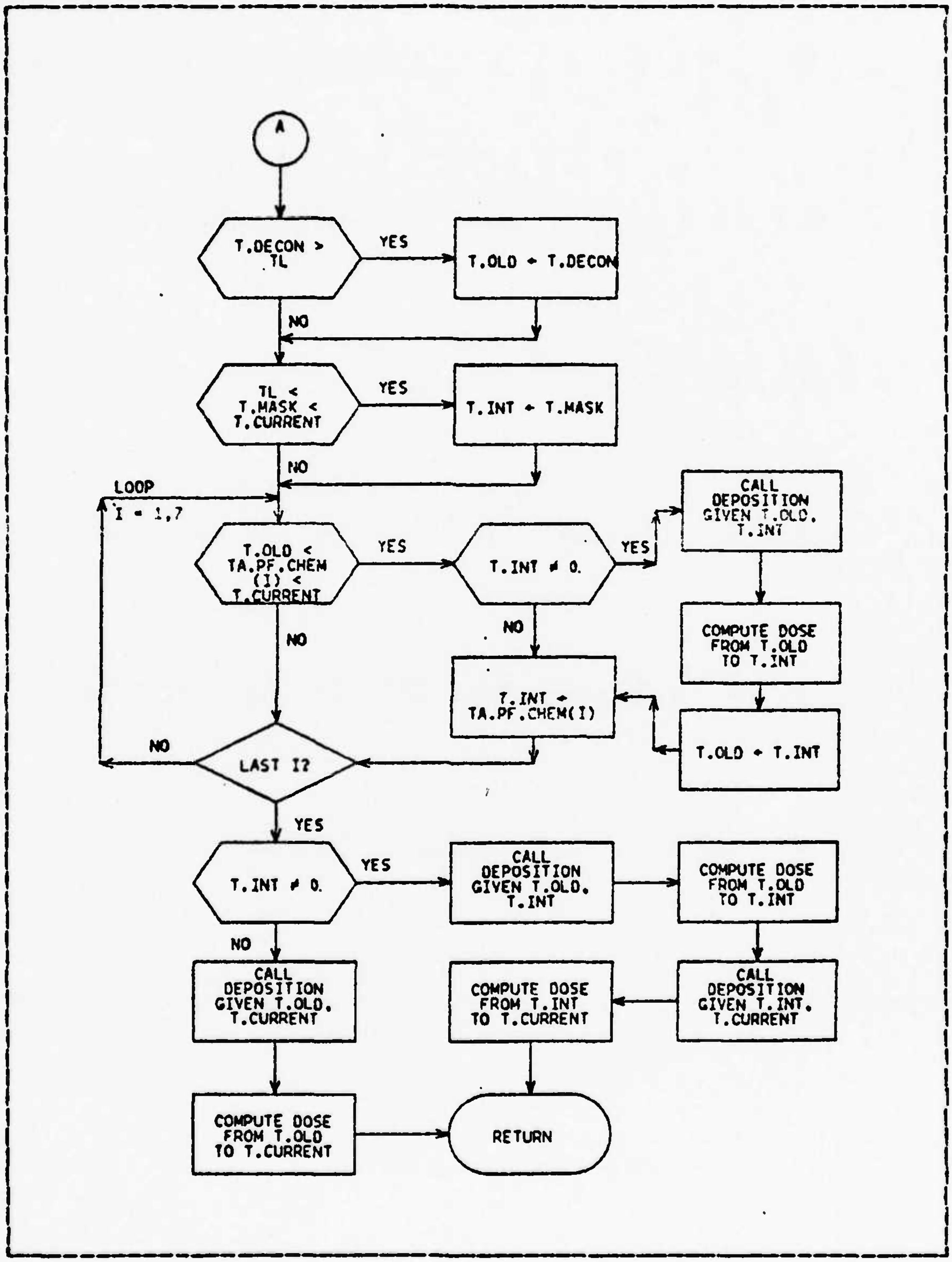

Figure 3.35 Routine DOSE3, Continuation A.

3. If the CP = 3 (bunker) or 4 (foxhole), then the PERSON cannot be moving at the current time. If he had been moving, but had stopped and gotten in the bunker or foxhole, he will have contaminated himself to the level found on the ground, adjusted by a pickup factor. This situation can be handled through the normal routine DOSE2.
4. If the CP = 5 (in the open), then the soldier is moving on foot. It is assumed that as long as movement continues, and he remains standing, the only contamination that will occur will be on the legs, feet, and hands. Dosage will be computed accordingly depending upon the protection factor of these body areas. If the DEFNUM attribute is equal to 5, he is standing. Any other DEFNUM value indicates that he is no longer standing, so he will have become contaminated.
5. In all cases, the amount of agent contaminating the exterior of the collective or individual protection of the PERSON will be computed as the pickup factor for agent j, AG.PICKUP(j), times the ground deposition, DEP.G.CURR(j). It is assumed that the pickup rate will be a constant function of the ground deposition and that this pickup rate can be expressed in a single global array value in AG.PICKUP for each agent over the course of the simulation (or until changed in the main simulation).

The routine begins by adjusting the exterior deposition DEP.G.CURR by the AG.PICKUP factor for all agents. The next check made by the routine sees if the time that decontamination is complete is greater than or equal to the current time. If is is, then the dosage received has been computed with the DECON routine and so the DOSE3 calculations are not needed. The routine will add the average dosage accumulated over DELT during decontamination, stored

in the array AGA.DECCN.DOSE, to the accumulated dosage value in array AGA.CUMDOSE, for each agent, then return to CROSSING.

The next check that is made is to see if the dosage calculations pertain to the one exceptional situation - a CP value and DEFNUM value of 5, indicating a PERSON crossing on foot, remaining upright. If the case is not exceptional, the normal dosage calculations apply, so the routine DOSE1 is called. Otherwise, the same general procedures as are used in DOSE1 are applied, only dosage is only accumulated over the body areas 5, 6 and 7. The actual dosage calculations are contained in Appendix A.

If T.DECON was in the current interval DELT, the routine sets the beginning of the interval, T.OLD, to the time that decontamination was completed, T.DECON. If T.DECON is prior to the last update (or equal to zero), then decontamination is complete (or has not been scheduled).

The routine next checks to see if any other protective actions such as masking (T.MASK), changing protection (TA.PF.CHEM), etc.,are scheduled during DELT. If so, a local variable T.INT is assigned this value, and will be passed as an argument to the routine DEPOSITION. In either case, the deposition on the outside of the PERSON or his collective protection has been adjusted by the pickup factor.

Dosage calculations are performed only for body areas 5, 6 and 7. Details are found in Appendix A. After all dosage calculations have been performed, control is returned to CROSSING.

IV. MODEL ENHANCEMENTS AND EXTENSIONS

A. MODEL ENHANCEMENTS

There are several enhancements to the basic persistent chemical agent effects model presented in this thesis that can be made by an individual interested in implementing the model. The model structure has many hooks designed to make some of these enhancements easier to coordinate with the existing framework.

One major enhancement is the explicit addition of non-persistent agents to the model. This is not as big a task as it may at first seem, for several reasons. You may recall from the introduction the fact that persistency is primarily a matter of environment and means of dissemination, rather than agent type. The only agent class normally quoted in threat documents that is truly non-persistent is the class of blood agents. All other normally expected agents may require some degree of skin protection. As a result, many nations dictate in their doctrine that the reaction to any suspected chemical agent attack is the same - to treat it as if it where persistent, and so don full chemical protection. Only later, when tests with detector kits or other means have verified that no persistent threat is present, will protection be removed. This verification process may be time-consuming and deferred until much later in an active combat situation. As a result, the persistent agent effects model can be used to model the non-persistent agents as well, with no changes required for scenarios of relatively short duration.

It may be desireable, however, to model different doctrine, situations, or scenarios that call for a reduction in chemical protection. As a result, some modifications need to be made in the model to accommodate this. The attributes CONTAMINATED and T.CONTAM have been included to serve as a flag for contamination. It may be possible to combine these attributes with others in IF-type statements to change the logical flow. Alternatively, CHEMDET could have values 0, 1, 2, or 3 (no detection, detection of one, the other, or both).

Several points in logic and attribute assignment have been kept separate to accommodate non-persistent agent modelling. The attribute MASK and the value PFA.CHEM(2) may seem superfluous at first, since they both refer to the facial area and most likely refer to the same piece of protective gear (mask with hood). However, the MASK attribute refers to protection against inhalation hazards only, and a MASKLEAK refers only to leakage of vapor or aerosol. The PFA.CHEM(2) value refers to protection against percutaneous absorption. Thus, the MASK attribute can be used separately from the PFA.CHEM array in non-persistent situations. In logic, the separate parameters PC.MASK and PC.MOPP make it possible to differentiate between the assumption of a non-persistent chemical attack (PC.MASK) and a persistent attack (PC.MOPP). Some changes will have to be made to the DETECTION and SYMPTOM.DETECT routines to avoid the automatic assumption of full chemical protection and consideration of decontamination after detection. The dosage calculations will not require alteration; with a nonpersistent agent, DEP.G.CURR (the current ground deposition) will always equal zero so only an inhalation hazard will be calculated.

Implicit in the play of non-persistent agents is the requirement for the reduction of chemical protection. The very nature of a non-persistent agent will permit reduction in protection within the time frames normally associated with high-resolution simulations. Decision logic needs to be added to the main combat simulation to decide when tests are to be made to verify the absence of a chemical hazard, and removal of protection if warranted. This is normally accomplished on a unit, rather than individual, basis. Once the decision has been made to remove the protection, the actual removal can be ordered through changes in the array CHANGE.ORDER for each PERSON in the unit. Changes in the protection factors for body areas 1 through 7 can be accomplished using the current model; unmasking can be accomplished by assigning a value of 1 to CHANGE.ORDER(5) (body area 2), and separately changing the value of the attribute MASK to zero.

Any MOPP changes upon order (increasing or decreasing) may be accomplished by putting the PFA.CHEM (protection factor) values for all standard MOPP levels in an array and putting all PERSONs into sets by unit (which would normally be done anyway). Then for all PERSONs in a given unit, the values of CHANGE.ORDER(4) through CHANGE.ORDER(10) could be assigned the appropriate vector from the MOPP array. The pointer for the array CHANGE.ORDER is stored in the attribute CHEM.CHANGE.

Once the decision logic has been established for changing chemical protection, it will be possible to consider modelling the degradation resulting from a given level of protection. In Chapter 2 (Doctrine), the problems associated with wearing chemical protective garments were discussed. This degradation may be the primary reason for and the major effect of the employment of persistent chemical agents. It would not be possible to model this

degradation without a basic model framework such as that provided in this thesis. Now that the framework has been provided, implementations should include some type of degradation effects model. A degradation model would be dependent upon the main combat model employed and should interact with virtually all modules of the model.

The OHC (overhead cover) routine can be enhanced by explicitly modeling the distance of the PERSON from vehicles and bunkers that he might use, the capacity and availability of these to the PERSON, and using this information to provide a better representation of the actions that might be taken upon receiving a persistent agent attack.

First aid other than injection of a nerve agent antidote may be added to the CHEMCAS.EFFECTS routine. The use of the array A.ANTIDOTE, dimensioned by the number of agents to be played, allows the effects of the first aid to be explicitly considered. For example, a reduction factor might be applied to the dosage effects of a blister agent after decontamination was performed.

The proximity section of the DETECTION routine allows for some modelling of the NBC Warning & Reporting System by altering the CHEMDET status of the PERSON receiving the warning over the net. However, this only can be used when the warned unit is immediately threatened, as receipt of the warning will cause the adoption of full protection and causes the unit to assume that they are in the presence of contamination. Modelling NBC intelligence will require separate logic and implementation.

Partial and complete decontamination may be added to the model, with the attribute CONTAMINATED serving as a flag. Decision logic incorporated into the main combat simulation will be required, as partial and complete decontamination are normally unit functions performed on order rather than individual actions based on the situation and doctrine. It

is reccammended that separate routines be established to model this, possibly on a unit rather than individual level.

B. RECCOMMENDATIONS FOR FUTURE EFFORTS

The model presented in this thesis depends extensively upon the use of probabilities at decision points and probability distributions to model the time it takes to perform actions and the effectiveness of such actions. The validity of such a model depends heavily upon the assumptions made in deriving these distributions.

This problem is endemic throughout most stochastic chemical modelling effort, as data that provides a reasonable fit to the situation being modelled is often difficult, if not impossible, to obtain. Many models make implicit distributional (or binary yes/no) assumptions within the logic and thus seemingly avoid these difficulties; however, it becomes difficult to change or improve upon these assumptions as data becomes available. It is recommended that the user exercise the utmost care in deriving the parameters used in this model (almost all of which must be explicitly set by the user), document the justification of the figures used, and conduct a sensitivity analysis to see which parameters significantly affect the main combat model.

The detection routine may be be represented as a dynamic function of the situation and time rather than a repeated comparison against a probability distribution. The author is unaware of any models presently written that could usefully be incorporated in the present high-resolution persistent chemical agent effects model; this issue merits further research.

No synergism has been assumed between chemical agents simultaneously present on the battlefield. Interactions, both physical and physiological, should be examined for possible significance.

Pickup of chemical agents from a contaminated area has been treated as a simple percentage of the agent present, and transfer of such agents to uncontaminated areas have been ignored. Some engineering and test data are available on the issue; methods of practicably modelling the matter should be explored.

Interactions between conventional and chemical casualty-producing effects have not been considered. For example, the fragmentation effect of a chemical round has not been modelled; the effects of fragmentation on chemical protective garments has only implicitly been considered through a leakage factor. Studies tend to consider the questions separately; however, the issue of contamination of personnel bearing conventional wounds, and the decontamination and treatment thereof, may prove very important in a battle where persistent chemical agents are used. The related issue of evacuation and decontamination of chemical casualties is also worthy of future modelling effort.

APPENDIX A

DOSAGE CALCULATIONS

A. DOSAGE RECEIVED WHILE DECONTAMINATING

1. Assumptions

a. There exists ABS (j) = rate at which j is absorbed int the body such that

Absorbed dose j = ABS (j) * contaminated skin area * time (eqn A.1)

where ABS(j) = mg / sq cm - sec
skin area = sq cm
time = sec

Note that this assumes a constant absorption rate over time regardless of the amount of agent deposition or previous dose absorbed.

b. There exists DCR (j) = rate at which a soldier can decontaminate skin contaminated with agent j such that

Skin area contaminated = DCR(j) * initial deposition on skin * initial skin area contaminated * time (eqn A.2)

where DCR (j) = sq cm / mg - sec
deposition = mg / sq cm
area = sq cm
time = sec

Since we assume uniform deposition on the soldier, the concentration will be the same over the entire contaminated skin area at any given time.

c. Decontaminated skin is immediately covered, so no recontamination occurs.

d. Decontamination will not occur while there is significant liquid depositing itself on the body - the soldier will seek or improvise overhead cover. As a result, there is no increase in the skin concentration after decontamination has commenced. Condensation of vapor and settling of aerosols ont exposed skin during the time of emergency skin decontamination is negligable.

e. ABS(j) and DCR(j) may vary among soldiers and among agents, but they are constant for a given soldier - agent combination.

2. Derivation

At time t_o, when decontamination commences, the soldier has a given concentration (deposition) on a given amount of exposed skin.

Let C_o = Concentration on skin in mg

Let S_o = exposed skin surface in cm

Before decontamination, the concentration on the skin was

C = deposition rate * skin area * time - ABS(j) * skin area * time (eqn A.3)

or

C = (deposition rate - absorption rate) * skin area * time (eqn A.4)

At t , the deposition rate is negligable (by assumption). After decontamination commences, the skin concentration is no longer uniform.

The dose absorbed over any small interval t' is

S(t) * ABS(j) * t' if C(t) > ABS(j) * t' (eqn A.5)

or

$$\int_{t_o}^{t} S(t) * ABS(j)\ dt \qquad \text{if } C(t_o) > ABS(j) * (t-t_o)$$

(eqn A.6)

The dose D absorbed between t_o and some later time t is:

$$D = ABS(j) * \int_{t_o}^{t} (S_o - DCR(j) * C_o * t)\ dt = ABS(j) * \{(S_o * t - (DCR(j) * C_o * t^2/2)\} \Big|_{t_o}^{endpoint}$$

(eqn A.7)

The endpoint is t if t <= S_o/DCR(j) * C_o since at the end of t =S_o/DCR(j) * C_o all skin is decontaminated; the endpoint is S_o/DCR(j) * C_o if t > S_o/DCR(j) * C_o. The dose absorbed is then than the minimum of D as evaluated, or the maximum amount that was present to be absorbed. Let t' = (t - t_o).

If t' is less than or equal to S_o / DCR(j) * C_o:

$$D = ABS(j) * t' * [\ S_o - (DCR(j) * C_o * (t'/2))\ ]$$ (eqn A.8)

If t' is greater than S_o / DCR(j) * C_o:

$$D = ABS(j) * [\ S_o^2 / (DCR(j) * C_o * 2)\ ]$$ (eqn A.9)

If C_o is less than or equal to ABS(j) * (t - t_o):

$$D = C_o$$ (eqn A. 10)

Therefore, the dose is:

D = min [result from integration, C_o] (eqn A.11)

B. DOSAGE COMPUTATION UNDER NORMAL CIRCUMSTANCES

1. Inhalation Dose

The inhalation dose is that dose received from chemical agent aerosols, vapors, and suspended droplets in the air that are absorbed into the bloodstream via the respiratory tract. There are two ways in which an inhalation dose may be received:

a. Dosage Received Prior to Donning a Protective Mask

Let AGA.INHAL.FACTOR be a conversion factor representing the milligrams of agent inhaled into the respiratory tract that are absorbed into the bloodstream.
Units: mg into bloodstream / mg imhaled (dimensionless)

Let SW.BREATHING be the breathing rate of the individual, as a function of the mission and work rate (expressed in terms of VEH.SYS.TYPE, VEH.WPN.TYPE, and DEFNUM).
Units: cubic meters / sec

Let DEP(2) be the average concentration of agent in the air during the time interval of interest.
Units: mg / cubic meter

Let T.START be the beginning of the interval and T.END be the end of the interval.

Then the total inhalation dose (INHALE.DOSE) is:

INHALE.DOSE = AG.INHAL.FACTOR * DEP(2) * SW.BREATHING * (T.END - T.START) (eqn A.12)

b. Dosage Received Through a Leak in the Protective Mask.

If the MASKLEAK is the percentage of the outside concentration entering the mask due to a leak, then the total inhalation dosage INHALE.DOSE received will be:

INHALE.DOSE = MASKLEAK * AG.INHAL.FACTOR * DEP(2) * SW.BREATHING * (T.END - T.START) (eqn A.13)

2. Percutaneous Dose

The percutaneous dose is that dose received from liquid chemical agents that contact the skin and are absorbed into the bloodstream.

a. Percutaneous Dose Received

Let PFA.CHEM(i) be the protection factor of any clothing or gear covering the skin of body area i. PFA.CHEM(i) = 1 if the skin of body area i is exposed.
Units: mg contacting the skin / mg contacting the outer layer of protection (dimensionless)

Let ABS(j) be the rate of absorbtion of chemical agent (j) through the skin.
Units: mg / (sq cm skin surface)*(second)

Let DEP(1) be the average deposition of chemical agent on the protective clothing (or skin, if exposed) during the interval of interest.
Units: mg / sq cm

Let SKIN(i) be the surface area of the skin of body area i.
Units: sq cm

Let T.START be the beginning of the interval and T.END be the end of the interval.

Then the total percutaneous dose (SKIN.DOSE) is:

$$SKIN.DOSE = PFA.CHEM(i) * ABS(j) * DEP(1) * SKIN(i) * (T.END - T.START) \quad \text{(eqn A.14)}$$

C. COMPUTER ROUTINES USED TO COMPUTE DOSAGE

1. The Routine DOSE.COMPUTE

This routine was used to contain the dosage formulas stated in Appendix A. It can be called from the routine DOSE1.

2. The Routine DOSE3.COMPUTE

This routine is identical to DOSE.COMPUTE (above), except that it only assesses the percutaneous dose over body areas 5, 6, and 7. It is called by the routine DOSE3.

3. The Routine DECON.DOSE

This routine contains the formulas for computing the dosage received while decontaminating, as discussed in Appendix A.

CODE

```
ROUTINE DECON.DOSE GIVEN AREA,AGENT,T.DECON.D, AND DEP YIELDING DOSE
      PRINT 1 LINE THUS
ROUTINE DECON.DOSE CALLED
      DEFINE AREA AND AGENT AS 0-DIMENSIONAL, INTEGER VARIABLES
      DEFINE T.DECON.D, ENDPT AND CO AS 0-DIMENSIONAL, REAL VARIABLES
      DEFINE DEP AS A 1-DIMENSIONAL, REAL ARRAY
      DEFINE DOSE AS A 2-DIMENSIONAL, REAL ARRAY
      RESERVE DEP(*) AS N.AGENT
      RESERVE DOSE(*,*) AS 7 BY N.AGENT
      LET CO = DEP(AGENT) * SKIN(SIDE,AREA)
      LET ENDPT = SKIN(SIDE,AREA) / ( DCR(AGENT)*CO )
      IF T.DECON.D IS LE ENDPT
          LET DOSE(AREA,AGENT) = ABS(AGENT) * T.DECON.D *
            ( SKIN(SIDE,AREA) - (DCR(AGENT)*SKIN(SIDE,AREA)*T.DECON.D*0.5) )
      ELSE LET DOSE(AREA,AGENT)= ABS(AGENT) * ENDPT * SKIN(SIDE,AREA) * 0.5
      REGARDLESS
      LET DOSE(AREA,AGENT) = MIN.F( CO, DOSE(AREA,AGENT) )
      LET DOSE(AREA,AGENT) = A.ANTIDOTE(AGENT) * DOSE(AREA,AGENT)
      RETURN
END   ''OF ROUTINE DECON.DOSE
```

CODE

```
ROUTINE DOSE.COMPUTE GIVEN T.START, T.END, AGENT AND DEP
     DEFINE T.START, T.END, INHALE.DOSE AND SKIN.DOSE AS 0-DIMENSIONAL,
          REAL VARIABLES
     DEFINE AGENT AS A 0-DIMENSIONAL, INTEGER VARIABLE
     DEFINE DEP AS A 1-DIMENSIONAL, REAL VARIABLE
     RESERVE DEP(*) AS 2
     PRINT 1 LINE THUS
ROUTINE DOSE.COMP CALLED
     ''INHALATION DOSE
LIST AG.INHAL.FACTOR(AGENT) , DEP(2) ,
SW.BREATHING(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),DEFNUM(SOLDIER)),
T.END, T.START
     IF (T.MASK(SOLDIER) IS GE T.END)
          OR (T.MASK(SOLDIER) = 0)                 ''PRIOR TO MASKING
          LET INHALE.DOSE = AG.INHAL.FACTOR(AGENT) * DEP(2) *
     SW.BREATHING(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),DEFNUM(SOLDIER))
          * (T.END-T.START)
     ELSE IF MASKLEAK(SOLDIER) IS NOT EQUAL TO 0     ''MASK ON BUT LEAKS
          LET INHALE.DOSE = AG.INHAL.FACTOR(AGENT) * DEP(2) *
     SW.BREATHING(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),DEFNUM(SOLDIER))
          * (T.END-T.START) * MASKLEAK(SOLDIER)
     ALWAYS REGARDLESS
     ''PERCUTANEOUS DOSE
     LET SKIN.DOSE = 0
     FOR I = 1 TO 7, DO
          LET SKIN.DOSE = SKIN.DOSE + PFA.CHEM(I) * SKIN(SIDE,I) *
               MIN.F( ABS(AGENT)*(T.END- T.START) , DEP(1) )
     LOOP
     ''CUMULATIVE IV DOSE
     LET INHALE.DOSE = INHALE.DOSE * A.ANTIDOTE(AGENT)     ''FIRST AID
     LET SKIN.DOSE = SKIN.DOSE * A.ANTIDOTE(AGENT)     ''FIRST AID
     LET AGA.CUMDOSE(AGENT) = INHALE.DOSE + SKIN.DOSE + AGA.CUMDOSE(AGENT)
LIST INHALE.DOSE, SKIN.DOSE, AGA.CUMDOSE(AGENT)
     RETURN
END     ''OF ROUTINE DOSE.COMPUTE
```

CODE

```
ROUTINE DOSE3.COMPUTE GIVEN T.START, T.END, AGENT AND DEP
     DEFINE T.START, T.END, INHALE.DOSE AND SKIN.DOSE AS 0-DIMENSIONAL,
          REAL VARIABLES
     DEFINE AGENT AS A 0-DIMENSIONAL, INTEGER VARIABLE
     DEFINE DEP AS A 1-DIMENSIONAL, REAL VARIABLE
     RESERVE DEP(*) AS 2
     PRINT 2 LINES WITH T.START, T.END, AGENT, DEP(1) AND DEP(2) THUS
ROUTINE DOSE3.COMP CALLED GIVEN T.START = ***.*, T.END = ***.*,
  AGENT = **, DEP(1) = ****.** AND DEP(2) = ****.**
     ''INHALATION DOSE
     IF (T.MASK(SOLDIER) IS EQUAL TO 0) OR (T.MASK(SOLDIER) IS GE T.END)
          LET INHALE.DOSE = AG.INHAL.FACTOR(AGENT) * DEP(2) *
     SW.BREATHING(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),DEFNUM(SOLDIER))
          * (T.END-T.START)
     ELSE IF MASKLEAK(SOLDIER) IS NOT EQUAL TO 0
          LET INHALE.DOSE = AG.INHAL.FACTOR(AGENT) * DEP(2) *
     SW.BREATHING(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),DEFNUM(SOLDIER))
          * (T.END-T.START) * MASKLEAK(SOLDIER)
     ALWAYS REGARDLESS
     ''PERCUTANEOUS DOSE
     LET SKIN.DOSE = 0
     FOR I = 5 TO 7, DO
          LET SKIN.DOSE = SKIN.DOSE + PFA.CHEM(I) * SKIN(SIDE,I) *
               MIN.F( ABS(AGENT)*(T.END-T.START) , DEP(1) )
     LOOP
     ''CUMULATIVE IV DOSE
     LET AGA.CUMDOSE(AGENT) = INHALE.DOSE + SKIN.DOSE + AGA.CUMDOSE(AGENT)
LIST INHALE.DOSE, SKIN.DOSE, AGA.CUMDOSE(AGENT)
     RETURN
END     ''OF ROUTINE DOSE3.COMPUTE
```

APPENDIX B
GLOSSARY

A. CONVENTIONS USED IN NAMING VARIABLES

Several conventions were followed in deriving variable names used in this model. An understanding of these conventions will assist in the understanding of the routines found in this thesis. They are:

1. A used as a prefix (e.g.,A.ROUND), or found at the end of a prefix (e.g.,TA.PF.CHEM) indicates an array. Normally this array will have an attribute pointer.
2. AG used as a prefix refers to the agents. If the array is singly- dimensioned, the dimension will be N.AGENT. If it has two dimensions, the last dimension will be N.AGENT.
3. AL as a prefix refers to attributes or characteristics of alarm systems.
4. D as a prefix refers to an array that holds a probability distribution, or in the case of D.IMPAIR and D.INCAP only, are used to generate numbers from a probability distribution. Other than the two exceptions mentioned above, the last dimension of the array is three; the first value in that dimension is the distribution type; the other two are the parameters of the distribution.
5. DEP as a prefix refers to the deposition or air concentration of the agents. The attributes DEP.AIR and DEP.GND point to these N.AGENT dimensioned arrays.
6. DT as a prefix indicates arrays that hold probability distributions for times taken to perform actions. The last dimension is of size three, with the same values as are given for the "D" prefix above.

7. N as a prefix indicates global variables used to indicate the number of entities or critical parameters to be modelled. These values are used in DEFINE statements and DO LOOPs.
8. OLD as a prefix indicates a value that has been retained from the previous iteration.
9. PC as a prefix stands for Probability (Chemical). It was used in lieu of a simpler "P" prefix to avoid problems with SIMSCRIPT generated arrays. These variables hold probabilities; they are used to direct the actions that will be taken by all PERSONs modelled.
10. PF as a prefix stands for Protection Factor. The arrays indicate values relating to the protection factor afforded each of seven body areas, and their last dimension is of size seven.
11. T as a prefix is used for times. When used as temporary attributes, they indicate either the time that a (dimensionless) event occurred, such as detection, or the time that an action was completed.
12. TA as a prefix refers to the arrays that hold time values.
13. VEH as a prefix refers to attributes or characteristics of vehicles.
14. The "D" suffix is used to refer to the time that it actually took to perform an action (e.g.,T.NAA.D refers to the time it takes to inject an antidote). It originally stood for "don", the time required to don the mask or protective gear, but for conformity it has been used with all performance times.

B. VARIABLE DEFINITIONS

A.ANTIDOTE GLOBAL VARIABLE (1-D) REAL

This variable is used to reduce the dosage for each agent by multiplying the accumulated dosage by the appropriate array element. It is initialized at 1 in the main (driver) program when the array is created. The pointer to the array is stored in the attribute ANTIDOTE. Currently, only the array elements corresponding to the nerve agents are modified - they are set equal to the value found in NAA.FACTOR by the routine NAA

Dimensions: N.AGENT

Value: NAA.FACTOR for nerve agents; a suitable reduction factor for other agents.

A.ROUND GLOBAL VARIABLE (2-D) REAL

This array forms a queue in which are stored the time and chemical/nonchemical nature of each round landing sufficiently near to the PERSON during DELT to cause the PERSON to react (he was in the effects ellipse of the round). The pointer to the array is stored in the attribute ROUND. Each time a round impacts and the PERSON is placed in the set corresponding to all personnel affected, the round time and nature should be added to the queue. The queue length at any time is stored in the attribute RDPTR.

Dimensions:(A number large enough to accomodate all rounds landing close enough to affect the PERSON) by 2

Value:
1st dimension:The time that the round impacted.
2nd dimension:
0 - if the round is not chemical
1 - if the round is chemical

ABS GLOBAL VARIABLE (1-D) REAL

This array stores the absorption rate of each agent through exposed skin. It is used to convert the depostion on the skin in mg/sq.cm. to the intravenous dose in mg.
Units : mg/sq.cm - sec

Dimension: N.AGENT

Value: As given above.

AG.AL.THRESH GLOBAL VARIABLE (2-D) REAL

This variable provides the concentration of each agent in mg/m that will cause a chemical agent alarm to sound a warning.

Dimensions: N.SIDE by N.AGENT

Value: As given above, for each side.

AG.CUMDOSE TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to AGA.CUMDOSE, which holds the accumulated dosage for each agent.

AG.DECAY GLOBAL VARIABLE (1-D) REAL

This array provides the amount of decay of each agent due to weathering that can be expected to occur in the interval DELT. It is multiplied by the deposition DEP.G.OLD at the beginning of the interval to yield the value at the end of the interval.

Dimensions: N.AGENT

Value: As given above, for each agent.

AG.DECON.DOSE TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array AGA.DECON.DOSE, which stores the average dosage received during each interval DELT during the decontamination process

AG.IMPAIR TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array AGA.IMPAIR, which gives the dosage threshold of the PERSON for impairment.

AG.INCAP TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array AGA.INCAP, which gives the dosage threshold of the PERSON for incapacitation.

AG.INHAL.FACTOR GLOBAL VARIABLE(1-D) REAL

This array stores the conversion factor used to convert the mg. of agent inhaled into the lungs into an equivalent intravenous dose.
Units: Dimensionless

Dimension: N.AGENT

Value: As given above, for each agent.

AG.LETH TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array AGA.LETH, which gives the lethal dosage threshold of the PERSON.

AG.PICKUP GLOBAL VARIABLE (1-D) REAL

This array serves as a conversion factor to convert the deposition on the ground DEP.G.CURR in a contaminated area to the deposition that would be found on the surface of personnel and vehicles crossing that area - thus, it represents the percentage of the agent picked up in traversing a contaminated area.

Dimension: N.AGENT

Value: As given above, for each agent

AGA.CUMDOSE GLOBAL VARIABLE (1-D) REAL

This array holds the accumulated intravenous (IV) dosage for each agent. It is incremented in the DOSE1, DOSE2, and DOSE3 routines.

Dimension: N.AGENT

Value: The dosage in mg accumulated up to the current time

AGA.DECON.DOSE GLOBAL VARIABLE (1-D) REAL

This array holds the average dosage for each agent, in mg, that the PERSON will receive during each DELT interval while he is performing decontamination. It is used to increment the accumulated dosage array AGA.CUMDOSE for every DELT interval during which the PERSON is performing decontamination. The DECON2 routine will compute this value.

Dimension: N.AGENT

Value: A dosage in mg, which is the total dose received during decontamination divided by the number of DELT intervals it takes to perform the decontamination.

AGA.IMPAIR GLOBAL VARIABLE (1-D) REAL

This array holds the impairment dose threshold values for each agent. This array is created when the PERSON is created by multiplying D.IMPAIR times the lethal dose threshold values created through a draw from D.LETH.

Dimension: N.AGENT

Value: As given above, for each agent

AGA.INCAP GLOBAL VARIABLE (1-D) REAL

This array holds the incapacitation dose threshold values for each agent. This array is created when the PERSON is created by multiplying D.INCAP times the lethal dose threshold values created through a draw from D.LETH.

Dimension: N.AGENT

Value: As given above, for each agent

AGA.LETH GLOBAL VARIABLE (1-D) REAL

This array holds the lethal dose threshold values for each agent. This array is created when the PERSON is created by randomly drawing from the distribution found in the array D.LETH.

Dimension: N.AGENT

Value: As given above, for each agent

AGENT.TYPE GLOBAL VARIABLE (1-D) INTEGER

This array is used to store an integer used to identify the type of agent. All nerve agents should be given a value of 1; other positive integers can be used to denote other types of agent. It is used to check the type of agent when the nerve agent antidote is injected; if the agent type is nerve, the dosage will be reduced by NAA.FACTOR; if the type is not nerve, then no dosage reduction will be applied.

Dimension: N.AGENT

Value:
1 - For nerve agents

AL.MAX.DIST GLOBAL VARIABLE (1-D) REAL

This array holds the maximum distance from a PERSON to another PERSON or ALARM over which he would hear the alarm or notice the reaction of that other PERSON to a chemical hazard. Any PERSON or ALARM that has previously detected the presence of a chemical hazard will warn all other PERSONs within this distance of his position

Dimension: N.SIDE

Value: Derived from normal line-of-sight conditions and the expected distance that one could hear the standard alarm

ALARM TEMP. ENTITY

This entity represents the standard automatic alarm or detection device that, when it detects the presence of a chemical agent, will sound an alarm (or otherwise notify nearby personnel). It should be created in appropriate numbers when vehicles and units are created. It has 3 attributes: WARNING, X.ALARM, and Y.ALARM.

ALPTR GLOBAL VARIABLE (1-D)

This array is used to store the pointer to the memory location where the temporary entity ALARM and its attributes are stored.

ANTIDOTE TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array A.ANTIDOTE, which stores the factors by which dosage of each agent will be reduced due to a first aid treatment

CHANGE.ORDER GLOBAL VARIABLE (2-D) REAL

This array is used to order changes in chemical protection external to the effects model. The array can be accessed by any routine by the name of each PERSON, and the changes in protection are ordered by changing the array values (they are initialized at -1 by the driver program). After changes have been made, they will be implemented the next time that CHEM.CHECK is called.

Dimensions: N.PERSON by 10

Value:
1st dimension: The name of the PERSON
2nd dimension:
1 - Enter 1 if you want the PERSON to mask
2 - Enter the value of the new CP category if you want the PERSON to change his collective protection (values 1 - 5)
3 - Enter 1 if you want the PERSON to create temporary overhead cover
4 - Enter the value of the protection factor for a new item of clothing or gear to be put on over body area 1
5 - Same as above for body area 2
6 - Same as above for body area 3
7 - Same as above for body area 4
8 - Same as above for body area 5
9 - Same as above for body area 6
10 - Same as above for body area 7

CHEM.CHANGE TEMP. ATTRIBUTE INTEGER

This attribute stores the pointer to the array CHANGE.ORDER, which is used to order changes in

chemical protection external to the chemical effects model.

CHEMDET TEMP. ATTRIBUTE INTEGER

This attribute shows if the PERSON has detected the presence of a persistent chemical agent hazard as of the previous iteration of CHEM.CHECK. A detection in the current DELT iterval will cause a change in this attribute at the beginning of the iteration for the following DELT interval.

Values:
0 - indicates no detection
1 - indicates detection

CHEMSIT GLOBAL VARIABLE INTEGER

This variable indicates the current situation facing the PERSON during this iteration. The value is determined by CHEM.CHECK at the beginning of the iteration over this PERSON.

Values:
0 - The PERSON is stationary and has not been directly attacked by (in the immediate effects ellipse of) a chemical agent munition
1 - The PERSON is in the immediate effects ellipse of a chemical agent munition. He may be stationary or moving
2 - The PERSON is moving in an area of previously deposited contamination. There is no airborne agent present
3 - The PERSON is moving in an area where there is still agent in the air (it has not all deposited on the ground), and has not been directly attacked by a chemical munition

COLOR TEMP. ATTRIBUTE INTEGER

An attribute used in STAR, this indicates the side to which the entity belongs.

Values: Any nonnegative integer

CONTAMINATED TEMP. ATTRIBUTE INTEGER

This attribute indicates if there is contamination over the entire surface of the PERSON or his collective protection

Values:
0 - No contamination over all surfaces
1 - Contamination present on all surfaces

CP TEMP. ATTRIBUTE INTEGER

This attribute indicates the current level of collective protection afforded the PERSON

Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

CREW SET (1-D)

This set is created for each vehicle. Filed in the set are the PERSONs that form the crew of the vehicle

D.IMPAIR GLOBAL VARIABLE (1-D) REAL

This array is used to determine the impairment threshold dose for the PERSON. It represents the fraction of the lethal dose for each agent that would cause impairment. The thresholds are created by multiplying this array by the lethal dose thresholds stored in the array AGA.LETH.

Dimension: N.AGENT

Value: Any fraction between 0 and 1

D.INCAP GLOBAL VARIABLE (1-D) REAL

This array is used to determine the incapacitation threshold dose for the PERSON. It represents the fraction of the lethal dose for each agent that would cause incapacitation. The thresholds are created by multiplying this array by the lethal dose thresholds stored in the array AGA.LETH.

Dimension: N.AGENT

Value: Any fraction between 0 and 1

D.LETH GLOBAL VARIABLE (2-D) REAL

This array is a distribution used to determine the lethal threshold dose for the PERSON. A random draw from the distribution for each agent will establish the lethal dose of that agent for the PERSON

Dimensions: N.AGENT by 3

Values:
1 - The type of distribution (see DISTRIB, below) 1 - 6
2 - The first parameter of the distribution

3 - The second parameter of the distribution, if any. The value can be left at 0 (the initial value when the array was reserved) if there is no second parameter

D.MSKLEAK GLOBAL VARIABLE (2-D) REAL

This array provides the probability distribution for the leakage of the protective mask. The variable MASKLEAK, the percentage of leakage of the mask to vapors, is drawn from it using the function DISTRIB

Dimensions: N.SIDE by 3

Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

D.PF.LEAK GLOBAL VARIABLE (2-D) REAL

This array provides the probability distribution for determining the amount of leakage to liquid agents found in the items of protective clothing that cover the seven body areas. The array elements PFA.LEAK are drawn from the distribution.

Dimensions: 7 (the number of body areas) by 3

Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DEFNUM TEMP. ATTRIBUTE INTEGER

This attribute gives the relative defilade of the PERSON at any given time

Values:
1 - in a foxhole
2 - prone
3 - crawling
4 - kneeling or sitting
5 - standing

DELT GLOBAL VARIABLE REAL

The variable DELT is a user-supplied parameter that gives the time interval between iterations of CHEM.CHECK. It is recommended that this interval be on the order of 10 seconds in length

DEP.A.CURR GLOBAL VARIABLE (1-D) REAL

This array holds the current values for the concentration of agent(s) in the air (at a height

of 2 meters) at the location of the PERSON. This information is supplied by NUSSE II or some equivalent model.
Units: mg / cubic meter

Dimension: N.AGENT

Values: As given above for each agent

DEP.A.OLD GLOBAL VARIABLE (1-D) REAL

This array holds the most recent values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON. This information was obtained during the last iteration of the model.
Units: mg / cubic meter

Dimension: N.AGENT

Values: As given above for each agent

DEP.AIR TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array DEP.A.CURR, which stores the current agent concentration in the air.

DEP.G.CURR GLOBAL VARIABLE (1-D) REAL

This array holds the current values for the deposition on the ground at the location of the PERSON. These values are supplied by NUSSE II or some equivalent model
Units: mg/ sq. cm

Dimension: N.AGENT

Values: As given above for each agent

DEP.G.OLD GLOBAL VARIABLE (1-D) REAL

This array holds the most recent values for the deposition on the ground at the location of the PERSON. This information was obtained during the last iteration of the model.
Units: mg/ sq. cm

Dimension: N.AGENT

Values: As given above for each agent

DEP.GND TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array DEP.G.CURR, which stores the current values for the deposition on the ground.

DEP.RED GLOBAL VARIABLE (3-D) REAL

This array provides the conversion factor to convert the deposition of liquid agent or the concentration of airborne agent outside of the PERSON's collective protection to the effective concentration inside the protection or on the PERSON. It is multiplied by DEP.A.CURR (The first element in the last dimension) and by DEP.G.CURR (The second element) to yield the effective concntrations and depositions inside the collective protection, respectively. It is used only for CP categories 3, 4 and 5. (CP categories 1 and 2 are represented by SW.BREATHING).

Dimensions: N.AGENT by 3 by 2

Values:
1st dimension: The indices represent the various agents
2nd dimension: The indicices indicate the three non-vehicular degrees of collective protection. They are:
    1 - Bunker or building (CP=3) or foxhole (CP=4) with temporary overhead cover (T.OHC not equal to zero)
    2 - Foxhole with no overhead cover
    3 - In the open (CP=5) with temporary overhead cover
3rd dimension:
    1 - The fraction used to convert the air concentration
    2 - The fraction used to convert the ground deposition

DISTRIB REAL FUNCTION

The function distrib accepts a pointer to the last dimension of the probability distributions used in the model. It will then draw a random number from any one of 6 specified distributions.

Values:
1st parameter: The type of distribution desired.
1 - Deterministic
    2nd parameter: The value desired
    3rd parameter: Not applicable
    2 - Uniform
    2nd parameter: The beginning of the interval
    3rd parameter: The end of the interval
    3 - Normal
    2nd parameter: The mean
    3rd parameter: The standard deviation
    4 - Lognormal
    2nd parameter: The mean
    3rd parameter: The standard deviation
    5 - Exponential
    2nd parameter: The mean
    3rd parameter: Not applicable
    6 - Beta
    2nd parameter: The power of x
    3rd parameter: The power of (1-x)

DT.DECON GLOBAL VARIABLE (4-D) REAL

This array provides a probability distribution from which the time it takes for emergency immediate decontamination of skin or clothing for each body area is drawn. This time does not include the time required to don protetive clothing after decontamination.

Dimensions: N.SIDE by N.AGENT by 7 body areas by 3

Values:
1st dimension: The side of the PERSON
2nd dimension: The agent concerned (in multiple agent situations, a factor MULT.AG.DECON will provide a way of adjusting the overall decontamination time)
3rd dimension: The body area concerned (1 through 7)
4th dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.DETECT GLOBAL VARIABLE (5-D) REAL

This array contains the probability distribution that is used to determine the glimpse probability of detection, PT.CHEMDET, of a persistent chemical agent hazard, based on noticing physical signs, during the interval DELT. If PT.CHEMDET is greater than or equal to a uniform (0,1) random number, detection will have occurred during DELT. Because the variable PT.CHEMDET is a probability, only a uniform or deterministic distribution (with parameter(s) between 0 and 1) or a beta distribution can be used.

Dimensions: 4 by N.AGENT by 5 by 2 by 3

Values:
1st dimension: The chemical situation CHEMSIT + 1 (the +1 is to avoid having an index of zero)
2nd dimension: The agent present
3rd dimension: The collective protection category CP (1 thru 5)
4th dimension: The value of the attribute MASK + 1 (mask off or on)
5th dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.MASK GLOBAL VARIABLE (2-D) REAL

This array holds the probability distribution used to determine the time required to don the protective mask. The temporary T.M.D is drawn from the distribution; when added to the current simulation time T.CHEMCURR, this provides the time at which the mask was donned, T.MASK.

Dimensions: N.SIDE by 3

Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.NAA GLOBAL VARIABLE (2-D) REAL

This array holds the probability distribution used to determine the time required to inject the nerve agent antidote. The temporary variable T.NAA.D is drawn from the distribution and, when added to T.CHEMCURR, sets the time at which the injection was complete, T.NAA

Dimensions: N.SIDE by 3

Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.OHC GLOBAL VARIABLE (3-D) REAL

This array holds the probability distribution used to determine the time required to reach or create overhead cover. The temporary variable T.OHC.D drawn from it is added to T.CHEMCURR to yield the time that the collective protection was reached (T.CP) or the time at which the overhead cover was completely over the body (T.OHC).

Dimensions: N.SIDE by 3

Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.PF GLOBAL VARIABLE (4-D) REAL

This array holds the probability distribution used to determine the time required to don a given item of chemical protective clothing, for each body area. The temporary variable T.PF.D is drawn from the distribution; when added to T.CHEMCURR, this yields the time at which the clothing was donned, TA.PF.CHEM(i) for body area i.

Dimensions: N.SIDE by 3

Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

ESSENCE TEMP. ATTRIBUTE INTEGER

This attribute is used to store the pointer of the entity UNIT (not modelled in the chemical effects model, but included in the STAR implementation) associated with the entity PERSON. For further details, see Appendix D, Section 2.

MASK TEMP. ATTRIBUTE INTEGER

This attribute indicates if the PERSON is wearing the chemical protective mask.

Value:
0 - if the mask is not being worn (off)
1 - if the mask is being worn (on)

MASKLEAK TEMP. ATTRIBUTE REAL

This attribute indicates the amount of leakage (if any) that the mask will leak to vapors and aerosols. It is multiplied by the ouside concentration of agent at the PERSON's location, DEP.A.CURR, to yield the effective concentration of agent inside the mask. The value is drawn from the distribution D.MSKLEAK

Values:
0 - If the mask does not leak
A fraction between 0 and 1 if the mask does leak

MIN.A.CHEM GLOBAL VARIABLE (1-D) REAL

This array provides the minimum significant level of air concentration for each agent. If the concentration is below this value, it is treated as if there were no agent present.

Dimension: N.AGENT

Values: The minimum significant concentration for each agent

MIN.G.CHEM GLOBAL VARIABLE (1-D) REAL

This array provides the minimum significant level of ground deposition for each agent. If the deposition is below this value, it is treated as if there were no agent present.

Dimension: N.AGENT

Values: The minimum significant deposition for each agent

MULT.AG.DECON GLOBAL VARIABLE (1-D) REAL

This array provides a means of adjusting the time it takes to decontaminate a given body area, T.DECON.D, drawn from DT.DECON, to allow for the presence of more than one agent on the skin. If there is a second agent present, T.DECON.D will be multiplied by MULT.AG.DECON to yield the time required to decontaminate both agents simultaneously. If there are three agents, T.DECON.D will be multiplied by MULT.AG.DECON twice; etc.

Dimension: N.SIDE

Value: The multiplication factor for the side the PERSON is on

N.AGENT GLOBAL VARIABLE INTEGER

This variable gives the maximum number of agents that will be used in a given scenario. It is used to dimension all arrays dependent on the agent type, and set the value for all "DO LOOPS" that iterate over the agent type.

Value: As given above

N.ALARM GLOBAL VARIABLE INTEGER

This variable gives the number of ALARMs created.

Value: As given above

N.PERSON GLOBAL VARIABLE INTEGER

This variable gives the number of PERSONs created.

Value: As given above

N.SIDE GLOBAL VARIABLE INTEGER

This variable gives the total number of sides (forces) to be played in the sceanrio. It may be simply 1 (single side scenario), 2 (RED on BLUE or equivalent) or greater than two, if allied and third-party forces are played.

Value: As given above

N.VEH.SYS.TYPE GLOBAL VARIABLE INTEGER

This variable gives the number of vehicle system types played in the scenario. The two attributes, system type and weapon type are used to identify particular vehicle types.

Value: As given above

N.VEH.WPN.TYPE GLOBAL VARIABLE INTEGER

This variable gives the number of vehicle weapon types played in the scenario. The two attributes, system type and weapon type are used to identify particular vehicle types.

Value: As given above

N.VEHICLE GLOBAL VARIABLE INTEGER

This variable gives the total number of vehicles created.

Value: As given above

NAA.FACTOR GLOBAL VARIABLE (1-D) REAL

This array provides the reduction factor used to reduce the effective intravenous dosage to account for the effect of a nerve agent antidote. This value is placed in the array A.ANTIDOTE when a nerve agent antidote is injected. When A.ANTIDOTE is multiplied by the current IV dosage contained in AGA.CUMDOSE, the nerve agent dosage will be reduced by the NAA.FACTOR.

Dimension: N.SIDE

Value: The reduction factor as given above

NAME TEMP. ATTRIBUTE INTEGER

This attribute consists of an index number used to identify a particular PERSON. Normally, it is the number of the DO LOOP iteration index.

Value: As given above

NUMBER TEMP. ATTRIBUTE INTEGER

This attribute consists of an index number used to identify a particular VEHICLE. It may be the number of the DO LOOP iteration index, or some type of vehicle bumper or serial number.

Value: As given above

OLD.DOSE GLOBAL VARIABLE (1-D) REAL

This array is used to store the values for the accumulated dosage as of end of the previous iteration. It is used to determine times at which impairment, incapacitation, or death occured (see routine CHEMCAS.EFFECTS, Chapter 3, Section E) It is set by the model in the routine UPDATE.

Dimension: N.AGENT

Value: As given above

OLDCP GLOBAL VARIABLE INTEGER

This variable gives the value for the most recent collective protection category that the PERSON was in, if he changed categories during DELT. It is set equal to the current CP value at the beginning of the iteration by the routine UPDATE; if the CP category changes for any reason, the old category is stored in OLDCP for the remainder of the iteration and the new CP category is stored in the attribute CP. It is used to accurately determine the reduction in concentration or deposition caused by the CP.

Value: As given above

OLDX TEMP. ATTRIBUTE REAL

This attribute gives the X coordinate of the location of the PERSON at the time of the previous iteration.

Value: As given above

OLDY TEMP. ATTRIBUTE REAL

This attribute gives the Y coordinate of the location of the PERSON at the time of the previous iteration.

Value: As given above

OPEN.CLOSED TEMP. ATTRIBUTE INTEGER

This VEHICLE attribute tells if the vehicle is open or closed. It is used to determine the leakage of agent into the vehicle, by setting an index in SW.NBC.FILTER

Value:
0 - if the vehicle is open
1 - if the vehicle is closed

PC.ACT.OHC GLOBAL VARIABLE (2-D) REAL

This array provides the probabilities that an individual will choose a particular one of three alternative actions in seeking or creating overhead cover. A uniform (0,1) random number is drawn and compared first to the first element in the second dimension - If this number is less than that element of PC.ACT.OHC, the first action is chosen (enter a vehicle). If the number is greater than or eaqual to the first element, but less than the second element of the second dimensicn, the second action will be chosen (enter a bunker).

Otherwise, the third action is chosen (create temporary overhead cover). For details, see routine OHC (Chapter 3, Section 4)

Dimensions: N.SIDE by 2

Values:
1st dimension: The number of the side the PERSON is on
2nd dimension:
1 - The probability of choosing action number 1
2 - The probability of choosing action number 2, added to the first probability

PC.DEL.DECON GLOBAL VARIABLE (1-D) REAL

This array provides the probabilities of choosing to decontaminate after symptoms of chemical agent poisoning have appeared. If decontamination is chosen, it will consist of removing all clothing and gear, decontaminating the entire body, and replacing the clothing with full chemical protective clothing. This option is offered when the routine DECON is called from the routine SYMPTOM.DETECT.

Dimension: N.SIDE

Values: The probability of performing delayed decontamination

PC.IMM.DECON GLOBAL VARIABLE (1-D) REAL

This array provides the probabilities of choosing to decontaminate immediately after discovering the presence of a chemical agent hazard. This is prior to any verification that the hazard in fact does exist. If decontamination is chosen, it will consist of first decontaminating exposed skin, then any clothing that is not chemical protective. After decontamination has been completed, all areas of the body will be covered by full chemical protective clothing. This option is offered when the routine DECON is called immediately after detection occurs.

Dimension: N.SIDE

Values: The probability of performing immediate decontamination

PC.MASK GLOBAL VARIABLE (1-D) REAL

This array contains the probability of a PERSON treating an artillery attack nearby as a nonpersistent chemical agent attack. If the PERSON does regard the attack as possibly nonpersistent, he will mask but will not don protective clothing, nor will he be considered to have detected the presence of a persistent chemical agent hazard.

Dimension: N.SIDE

Values: The probability as given above

PC.MOPP GLOBAL VARIABLE (1-D) REAL

This array contains the probability of a PERSON treating an incoming artillery attack nearby as a persistent chemical agent attack. If the PERSON does regard the attack as possibly persistent, he will don full protective clothing, and he will be considered to have detected the presence of a persistent chemical agent hazard.

Dimension: N.SIDE

Values: The probability as given above

PC.MSKLEAK GLOBAL VARIABLE (1-D) REAL

This array contains the probability that a protective mask will leak with respect to vapors and aerosols as a result of tears, combat damage, improper fitting or donning, etc. If the mask will leak, the leakage amount is drawn from D.MSKLEAK.

Dimension: N.SIDE

Values: The probability as given above

PC.NAA GLOBAL VARIABLE (1-D) REAL

This array contains the probability that the PERSON, as a result of poor training or panic, will inject himself with the nerve agent antidote under circumstances other than the appearence of nerve agent symptoms, such as detection of the agent or the appearence of symptoms caused by a chemical agent other than the nerve agent.

Dimension: N.SIDE

Values: The probability as given above

PC.OHC GLOBAL VARIABLE (1-D) REAL

This array contains the probability that a soldier that has detected the presence of a persistent agent hazard by any means will assume that the agent is still falling toward the ground, and as a result will seek overhead cover.

Dimension: N.SIDE

Values: The probability as given above

PC.PF.LEAK GLOBAL VARIABLE (2-D) REAL

This array gives the probability that the item of full chemical protection covering a given body area will leak with respect to liquid agents. This leakage may be caused by tears, combat damage, improper fitting or donning, some agent being trapped under the garment from inadequate or no decontamination. If the item will leak, the leakage amount is drawn from D.PF.LEAK.

Dimension: N.SIDE by 7

Values:
1st dimension: The side that the PERSON is on
2nd dimension: The probability as given above for the body area 1 thru 7

PERSON TEMP. ENTITY

This temporary entity is used to model any combatant on the battlefield.

PERSPTR GLOBAL VARIABLE (1-D) INTEGER

This array is used to store the pointer to the memory location where the temporary entity PERSON and its attributes are stored.

PF.CHEM TEMP. ATTRIBUTE INTEGER

This attribute stores the pointer to the array PFA.CHEM, which provides the protection factor for each of the seven body areas of the PERSON.

PF.LEAK TEMP. ATTRIBUTE INTEGER

This attribute stores the pointer to the array PFA.LEAK, which provides the percentage leakage with respect to liquid agents of the chemical protective clothing on each of the seven body areas of the PERSON.

PF.MAX GLOBAL VARIABLE (2-D) REAL

This array provides the protection factor for the item that provides full chemical protection for a given body area. Implicitly, this array also defines the maximum protective (full MOPP) level.

Dimensions: N.SIDE by 7

Values:
1st dimension: The side that the PERSON is on
2nd dimension: The protection factor for each body area, as explained above

PFA.CHEM GLOBAL VARIABLE (1-D) REAL

This array provides the current protection factor for each of the seven body areas of the PERSON. Implicitly, this array also defines the current protective (MOPP) level.

PFA.LEAK GLOBAL VARIABLE (1-D) REAL

This array provides the percentage leakage with respect to liquid agents of the chemical protective clothing on each of the seven body areas of the PERSON. The leakage may be caused by tears, combat damage, improper fitting or donning, some agent being trapped under the garment from inadequate or no decontamination. The determination of whether or not the item would leak was accomplished through a comparison to PC.PF.LEAK. If the item will leak, the PFA.LEAK value is drawn from D.PF.LEAK.

Dimension: 7

Values:
0 - If the item does not leak
A fraction between 0 and 1 if the item does leak

RDPTR TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the current length of the array A.ROUND. A.ROUND is a queue in which the time and chemical/nonchemical nature of each round landing sufficiently near to the PERSON during DELT to cause the PERSON to react are stored.

Value: The number of items in the queue stored in A.ROUND

ROUND TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array A.ROUND, which is a queue into which are placed the time and chemical/nonchemical nature of each round landing sufficiently near to the PERSON during DELT to cause the PERSON to react

SIDE GLOBAL VARIABLE INTEGER

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1

Value: COLOR(PERSON) + 1

SKIN GLOBAL VARIABLE (2-D) REAL

This array provides the skin area associated with each of the seven body areas. Different values are allowed for different sides to accomodate different coverages associated with items of the standard protective gear - for example, with one force a cloak could cover down to the knees; in another force a jacket which only covers down to the waist is used.
Units: square centimeters

Dimensions: N.SIDE by 7

Values:
1st dimension: The side the PERSON is on.
2nd dimension: The skin area associated with each body area

SOLDIER GLOBAL VARIABLE INTEGER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.

Value: SOLDIER = PERSPTR(NAME(PERSON))

SW.BREATHING GLOBAL VARIABLE (3-D) REAL

This array provides the breathing rate of the PERSON as a function of his activity. His activity is determined from his system and weapon type VEH.SYS.TYPE and VEH.WPN.TYPE, and his defilade DEFNUM.
Units:

Dimensions: N.VEH.SYS.TYPE by N.VEH.WPN.TYPE by 5

Values:
1st dimension: The VEH.SYS.TYPE of the PERSON
2nd dimension: The VEH.WPN.TYPE of the PERSON
3rd dimension: The breathing rate associated with the DEFNUM and the other two dimensions

SW.NBC.FILTER GLOBAL VARIABLE (6-D) REAL

This array provides the amount of leakage of agent through a vehicle, expressed as a percentage of the outside concentration. It is used to convert the concentration of agent in the air and deposition of agent on the exterior of the vehicle to an equivalent concentration and deposition inside the vehicle. The temporary variable PAX is used to store whether or not the PERSON is crew or passenger on the vehicle; the temporary variable HATCH is used to distinguish between a vehicle with overpressure working (CP=1); a vehicle without overpressure, closed; and either vehicle open (CP=2).

Dimensions: N.VEH.SYS.TYPE by N.VEH.WPN.TYPE by 2 by 3 by 2 by N.AGENT

Values:
1st dimension: The VEH.SYS.TYPE of the PERSON
2nd dimension: The VEH.WPN.TYPE of the PERSON
3rd dimension: PAX
PAX = 1 if PERSON belongs to a set CREW
PAX = 2 if the PERSON does not belong to a set CREW
4th dimension: HATCH
HATCH = 1 if CP = 1 (vehicle with operating overpressure system)
HATCH = 2 if CP = 2 and OPEN.CLOSED(VEHICLE) = 1 (vehicle without overpressure; closed)
HATCH = 3 if OPEN.CLOSED(VEHICLE) = 0
5th dimension: State of agent
1 - for liquid agent
2 - for vapor or aerosol
6th dimension: The agent type

T.AG.IMPAIR TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array TA.IMPAIR, which gives the time that the impairment dose threshold was reached for each agent.

T.AG.INCAP TEMP. ATTRIBUTE INTEGER

This attribute serves as a pointer to the array TA.INCAP, which gives the time that the incapacitation dose threshold was reached for each agent.

T.CHEMCURR GLOBAL VARIABLE REAL

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed. It is initially set at the time of the last iteration, TL; as events occur and times are assigned to them, this variable is incremented with the time of the event; as actions are taken, the variable is incremented by the time it took to perform that action. The next action, therefore, will begin at time T.CHEMCURR.

T.CHEMDET TEMP. ATTRIBUTE REAL

This attribute stores the time at which the PERSON detected the presence of a persistent chemical agent hazard. This detection may have occurred due to any of the four possible means of detection (see the DETECTION routine discussion in Chapter 3 for more detail).

Value: The time at which detection occurred

T.CONTAM TEMP. ATTRIBUTE REAL

This attribute gives the time at which contamination occurred over the entire surface of the PERSON or his collective protection. It is assigned a time when the attribute CONTAMINATED changes from 0 to 1.

Value: The time at which contamination occurred

T.CP TEMP. ATTRIBUTE REAL

This attribute provides the time at which the PERSON assumed his current level of collective protection.

Value: The time as given above

T.CURRENT GLOBAL VARIABLE REAL

This variable gives the current simulation time within the main combat model calling the chemical effects routines.

Value: The time as given above

T.DECON TEMP. ATTRIBUTE REAL

This attribute gives the time at which the process of decontamination was completed, to include the donning of full chemical protection after decontamination.

Value: The time as given above

T.LETH TEMP. ATTRIBUTE REAL

This attribute gives the time of death occuring as a result of an overdose of chemical agent. It is assigned the first time the dosage from any chemical agent passes its respective lethal dose threshold.

Value: The time as given above

T.MASK TEMP. ATTRIBUTE REAL

This attribute stores the time at which the PERSON finished donning his protective mask.

Value: The time as given above

T.NAA   TEMP. ATTRIBUTE   REAL

This attribute stores the time at which the PERSON finished injecting himself with a nerve agent antidote.

Value: The time as given above

T.OHC   TEMP. ATTRIBUTE   REAL

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.

Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)
The time as given above, if overhead cover exists.

T.PF.CHEM   TEMP. ATTRIBUTE   INTEGER

This attribute serves as a pointer to the array TA.PF.CHEM, which gives the time that the current level of individual chemical protection was donned, for each body area.

TA.IMPAIR   GLOBAL VARIABLE (1-D)   REAL

This array provides the time at which the impairment dose threshold was reached for each agent. Its pointer is stored in the attribute T.AG.IMPAIR.

Dimension: N.AGENT

Values:
0 - if the impairment dose threshold has not been met
The time as given above if the impairment dose threshold has been reached

TA.INCAP   GLOBAL VARIABLE (1-D)   REAL

This array provides the time at which the incapacitation dose threshold was reached for each agent. Its pointer is stored in the attribute T.AG.INCAP.

Dimension: N.AGENT

Values:
0 - if the incapacitation dose threshold has not been met

The time as given above if the incapacitation dose threshold has been reached

TA.PF.CHEM GLOBAL VARIABLE (1-D) REAL

This array provides the time that the current level of individual chemical protection was donned, for each body area. The pointer to this array is stored in the attribute T.PF.CHEM.

TL GLOBAL VARIABLE REAL

This variable gives the simulation time within the main combat model at the time of the last iteration.

Value: The time as given above

UPTR GLOBAL VARIABLE (1-D) REAL

This array is used as a convenience to call for a uniform (0,1) random number.

Dimension: 3

Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

VEH.NO TEMP. ATTRIBUTE INTEGER

This attribute consists of the index number used to identify the VEHICLE that the PERSON is on.

Value:
0 - The PERSON is not on a vehicle.
NUMBER(VEHICLE) that the PERSON is on, otherwise.

VEH.PTR GLOBAL VARIABLE (1-D) INTEGER

This array is used to store the pointer to the memory location where the temporary entity VEHICLE and its attributes are stored.

VEH.SYS.TYPE TEMP. ATTRIBUTE INTEGER

This attribute, along with VEH.WPN.TYPE, is used to identify a particular vehicle type.

Value: As given above

VEH.WPN.TYPE TEMP. ATTRIBUTE INTEGER

This attribute, along with VEH.SYS.TYPE, is used to identify a particular vehicle type.

Value: As given above

VEHICLE TEMP. ENTITY

This entity is used to model every vehicle on the battlefield.

WARNING TEMP. ATTRIBUTE INTEGER

This attribute of an ALARM tells if the ALARM has sounded. The ALARM will automatically sound a warning when the concentration of agent in the air at the location of the ALARM passes the threshold concentration set for that alarm in the global variable AG.AL.THRESH.

X.ALARM TEMP ATTRIBUTE REAL

This attribute gives the X coordinate of the location of the ALARM at the current simulation time, T.CURRENT.

Value: As given above

X.CURRENT TEMP. ATTRIBUTE REAL

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.

Value: As given above

Y.ALARM TEMP. ATTRIBUTE REAL

This attribute gives the X coordinate of the location of the ALARM at the current simulation time, T.CURRENT.

Value: As given above

Y.CURRENT TEMP. ATTRIBUTE REAL

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.

Value: As given above

APPENDIX C

SIMSCRIPT IMPLEMENTATION

A. ROUTINES

1. The Routine CHEM.CHECK

Purpose:

1. Drives the model and calls all other routines.
2. Updates the depositions, certain global variables, and schedules protection changes on order through the routine UPDATE.
3. Determines the chemical situation faced by each person.
4. Schedules automatic reactive measures (if any) after artillery rounds impact near a position.
5. Schedules a chemical detection, either directly or through a call to the routine DETECTION, based on the situation. When a chemical hazard is detected, schedules the appropriate reactive measures (seeking overhead cover, decontaminating, increasing protection).
6. Updates the dosage through a call to the routine DOSE1.
7. Assigns times at which dosage thresholds are reached, and reactions (if any) to symptoms, through the routine CHEMCAS.EFFECTS.

ROUTINES CALLED BY CHEM.CHECK

CHEMCAS.EFFECT
CROSSING
DECON
DETECTION
DISTRIB
DOSE1
MASKING
MOPP
OHC
UPDATE

LABELS USED WITHIN ROUTINE

DETECT.CHEM
DIRECT
DOSECOMP
REACT

TEMPORARY ATTRIBUTES OF PERSON INTEGER

CHEMDET

This attribute shows if the PERSON has detected the presence of a persistent chemical agent hazard as of the previous iteration of CHEM.CHECK.
Values:
0 - indicates no detection
1 - indicates detection

CONTAMINATED

This attribute indicates if there is contamination over the entire surface of the PERSON or his collective protection
Values:
0 - No contamination over all surfaces
1 - Contamination present on all surfaces

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

MASK

This attribute indicates if the PERSON is wearing the chemical protective mask.
Value:
0 - if the mask is not being worn (off)
1 - if the mask is being worn (on)

RDPTR

This attribute serves as a pointer to the length of the array A.ROUND.
Value: The number of items in the queue stored in A.ROUND

TEMPORARY ATTRIBUTES OF PERSON REAL

OLDX

This attribute gives the X coordinate of the location of the PERSON at the time of the previous iteration.

Value: As given above

OLDY

This attribute gives the Y coordinate of the location of the PERSON at the time of the previous iteration.
Value: As given above

T.CHEMDET

This attribute stores the time at which the PERSON detected the presence of a persistent chemical agent hazard.

T.CONTAM

This attribute gives the time at which contamination occurred over the entire surface of the PERSON or his collective protection. It is assigned a time when the attribute CONTAMINATED changes from 0 to 1.
Value: The time at which contamination occurred

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

T.OHC

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.
Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)
The time as given above, if overhead cover exists.

X.CURRENT

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.
Value: As given above

Y.CURRENT

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.
Value: As given above

GLOBAL VARIABLES INTEGER

CHEMSIT

This variable indicates the current situation facing the PERSON during this iteration.
Values:
0 - The PERSON is stationary and has not been directly attacked by (in the immediate effects ellipse of) a chemical agent munition
1 - The PERSON is in the immediate effects ellipse of a chemical agent munition. He may be stationary or moving
2 - The PERSON is moving in an area of previously deposited contamination. There is no airborne agent present
3 - The PERSON is moving in an area where there is still agent in the air (it has not all deposited on the ground), and has not been directly attacked by a chemical munition

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

A.ROUND (2-D)

This array forms a queue in which are stored the time and chemical/nonchemical nature of each round landing sufficiently near to the PERSON during DELT to cause the PERSON to react

Dimensions: (A number large enough to accomodate all rounds landing close enough to affect the PERSON) by 2
Value:
1st dimension: The time that the round impacted.
2nd dimension:
0 - if the round is not chemical
1 - if the round is chemical

DELT

The variable DELT is a user-supplied parameter that gives the time interval between iterations of CHEM.CHECK.

DEP.A.CURR (1-D)

This array holds the current values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON.
Units: mg / sq. cm
Dimension: N.AGENT
Values: As given above for each agent

MIN.A.CHEM (1-D)

This array provides the minimum significant level of air concentration for each agent.
Dimension: N.AGENT
Values: The minimum significant concentration for each agent

MIN.G.CHEM (1-D)

This array provides the minimum significant level of ground deposition for each agent.
Dimension: N.AGENT
Values: The minimum significant deposition for each agent

PC.MASK (1-D)

This array contains the probability of a PERSON treating an incoming artillery attack nearby as a nonpersistent chemical agent attack.

Dimension: N.SIDE
Values: The probability as given above

PC.MOPP (1-D)

This array contains the probability of a PERSON treating an incoming artillery attack nearby as a persistent chemical agent attack.
Dimension: N.SIDE
Values: The probability as given above

PC.OHC (1-D)

This array contains the probability that a soldier that has detected the presence of a persistent agent hazard by any means will assume that the agent is still falling toward the ground, and as a result will seek overhead cover.
Dimension: N.SIDE
Values: The probability as given above

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES REAL

RDTIME

This variable is used to store the earliest round impact time stored in the array A.ROUND (1st dimension).

U1 ; U2

These variables are used to store a random uniform (0,1) random number.

BRIEF EXPLAINATION OF CODE

LINE 3

Call to the routine UPDATE, which initializes certain temporary variables, assigns the deposition of each chemical agent at the location of the PERSON to the arrays DEP.G.OLD, DEP.G.CURR, DEP.A.OLD and DEP.A.CURR, and checks to see if any changes in protection category or individual protection have been ordered during the previous DELT seconds.

LINE 4

Initializes T.CHEMCURR to equal the time of the last CHEM.CHECK (time TL).

LINES 5 - 14

This section separates out several possible situations that the PERSON concerned might be involved in, which are stored in the variable CHEMSIT.

LINE 9

If the PERSON is moving, T.OHC is set to zero because he cannot have temporary overhead cover while moving.

LINES 14 - 16

If the PERSON is in CHEMSIT 2, all futher routine calls will be handled separately by routine CROSSING.

LINES 18 - 25

Checks to see if the PERSON has been contaminated at some previous time. If he has not, and his current deposition DEP.G.CURR is greater than MIN.G.CHEM, then he will be marked as contaminated by assigning a value of 1 to CONTAMINATED and a time of contamination T.CONTAM based on the ratio of the MIN.G.CHEM level to the current deposition level.

LINES 28, 35

If the PERSON regarded the attack as potentially chemical, T.CHEMCURR is assigned the time of the first round that impacted close enough to react to. RDTIME was first set at T.CURRENT, the latest possible time that a round possibly could have landed during DELT. Line 35 insures that the final value of RDTIME will be the earliest time in the queue.

LINE 29

If the individual has already detected the fact that he has been attacked by (or exposed to the hazards of) a chemical agent, then the program moves down to the dose computation sequence DOSE1.

LINES 30 - 36

Checks if the PERSON was in the immediate effects ellipse of any round during the last DELT seconds. The time of impact of any rounds close enough to have affected the PERSON concerned is stored in the first dimension of A.ROUND, while RDPTR, gives the length of the round queue. The second dimension of A.ROUND has a (0,1) bit stating whether or not any of those close rounds were chemical - if so, CHEMSIT is updated to be 1.

LINES 30 - 32

If the individual was not attacked, moves to the label DETECT.CHEM to see if detection will occur.

LINES 37 - 40

If a uniform (0,1) random number is less than PC.MASK, the PERSON has regarded the attack as conventional. The routine will then go directly to the detection sequence (label DETECT.CHEM).

LINES 42 - 44

Checks to see if the PERSON is in CP = 1. If he is, no reaction is necessary. The PERSON will have detected the event, with T.CHEMDET set equal to T.CHEMCURR. The next step will be to go to the label DOSECOMP, where the routine DOSE1 is called.

LINES 45 - 50

If the PERSON was not CP = 1, the routine checks to see if his mask is on. If not, MASKING is called. T.MASK is set to T.CHEMCURR. If MASK was set to 1 during the update routine, T.MASK has been set previously. T.CHEMCURR is set equal to T.MASK in either case.

LINES 56 - 60

If a uniform (0,1) random number is less than PC.MOPP, then the person will have detected the presence of chemical agent. T.CHEMDET is set equal to T.CHEMCURR. The routine next calls for the appropriate protective measures based on this detection by calling the routines OHC, DECON, and MOPP.

LINE 54

If the PERSON had decided not to mask and/or treat the attack as a persistent agent attack, the routine will proceed to the label "DETECT.CHEM".

LINES 61 - 62

The routine DETECTION is called to see if the PERSON will detect the presence of a chemical agent from signs or from proximity to others who have detected (or suspected and thus reacted to) the chemical hazard.

LINE 63

The routine DOSE1 is called to calculate the total dose received during the period DELT.

LINE 64

The routine CHEMCAS.EFFECTS is called. This routine takes the accumulated dose and determines if, based on that dose, impairment, incapacitation, or death could have occurred to that person during DELT.

CODE

```
ROUTINE CHEM.CHECK
     DEFINE U1,U2, RDTIME AS 0-DIMENSIONAL, REAL VARIABLES
     CALL UPDATE
     LET T.CHEMCURR = TL
     IF (X.CURRENT(SOLDIER) IS EQUAL TO OLDX(SOLDIER)) AND
        (Y.CURRENT(SOLDIER) IS EQUAL TO OLDY(SOLDIER))
        GO TO DIRECT
     REGARDLESS LET CHEMSIT = 3
     LET T.OHC(SOLDIER) = 0
     FOR J = 1 TO N.AGENT, DO
        IF DEP.A.CURR(J) IS GE MIN.A.CHEM(J), GO TO DIRECT
        REGARDLESS IF DEP.G.CURR(J) IS LT MIN.G.CHEM(J), GO TO DIRECT
     REGARDLESS LOOP
     LET CHEMSIT = 2
     CALL CROSSING
     RETURN
'DIRECT' PRINT 1 LINE THUS
LABEL DIRECT REACHED IN CHEM.CHECK
     IF CONTAMINATED(SOLDIER) IS NOT EQUAL TO 1
        FOR J = 1 TO N.AGENT, DO
           IF DEP.G.CURR(J) IS GE MIN.G.CHEM(J)
              LET CONTAMINATED(SOLDIER) = 1
              LET T.CONTAM(SOLDIER) =
                 ( (MIN.G.CHEM(J)/DEP.G.CURR(J))*DELT ) + TL
        REGARDLESS LOOP
     REGARDLESS
     LIST CHEMDET(SOLDIER), RDPTR(SOLDIER), CONTAMINATED(SOLDIER),
          T.CONTAM(SOLDIER)
     LET RDTIME = T.CURRENT
     IF CHEMDET(SOLDIER) IS NOT EQUAL TO 0, GO TO DOSECOMP
     OTHERWISE IF RDPTR(SOLDIER) IS EQUAL TO 0
        LET CHEMSIT = 0
        GO TO DETECT.CHEM
     OTHERWISE FOR K = 1 TO RDPTR(SOLDIER), DO
        IF A.ROUND(K,2) IS EQUAL TO 1, LET CHEMSIT = 1
        REGARDLESS LET RDTIME = MIN.F( RDTIME, A.ROUND(K,1) )
     LOOP
     LET U1 = DISTRIB( UPTR(*) )
     LIST U1, PC.MASK(SIDE)
     IF U1 IS GT PC.MASK(SIDE)
        GO TO DETECT.CHEM             ''SOLDIER WILL NOT REACT
     OTHERWISE LET T.CHEMCURR = RDTIME
     IF CP(SOLDIER) IS EQUAL TO 1
        LET T.CHEMDET(SOLDIER) = T.CHEMCURR
        GO TO DOSECOMP               ''IN VEHICLE WITH OVERPRESSURE
     OTHERWISE IF MASK(SOLDIER) IS NOT EQUAL TO 1  ''NOT ALREADY MASKED
        CALL MASKING
        LET T.CHEMCURR = T.MASK(SOLDIER)
     REGARDLESS IF (TL IS LE T.MASK(SOLDIER)) AND (T.MASK(SOLDIER)
        IS LE T.CURRENT)
        LET T.CHEMCURR = T.MASK(SOLDIER)
     REGARDLESS LET U2 = DISTRIB( UPTR(*) )
     LIST U2, PC.MOPP(SIDE)
     IF U2 IS GT PC.MOPP(SIDE)
        GO TO DETECT.CHEM   ''WILL NOT TREAT AS PERSISTANT CHEM ATTACK
     OTHERWISE
'REACT' LET T.CHEMDET(SOLDIER) = T.CHEMCURR
     CALL OHC GIVEN PC.OHC(SIDE)
     CALL DECON
     CALL MOPP
     GO TO DOSECOMP
'DETECT.CHEM' PRINT 1 LINE THUS
LABEL DETECT.CHEM REACHED IN CHEM.CHECK
     PERFORM DETECTION
'DOSECOMP' CALL DOSE1
     CALL CHEMCAS.EFFECTS
     RETURN
END     ''OF ROUTINE CHEM.CHECK
```

2. The Routine UPDATE

Purpose

1. Initializes certain global variables to the correct values for the PERSON being examined, such as DEP.G.OLD, DEP.A.OLD, OLD.DOSE, and OLDCP.
2. Gets the current ground deposition and air concentrations. If the deposition is less than that encountered previously, computes the current contamination level on the PERSON, taking weathering into account.
3. Updates CHEMDET, the attribute that gives the detection status of the PERSON.
4. Schedules changes in individual and collective protection (CP, OHC, MASK, and PF.CHEM) ordered by the main combat simulation.

ROUTINES CALLED BY UPDATE

DISTRIB
MASKING
NUSSEII

SETS

CREW (1-D)

TEMPORARY ATTRIBUTES INTEGER

CHEMDET

This attribute shows if the PERSON has detected the presence of a persistent chemical agent hazard as of the previous iteration of CHEM.CHECK.
Values:
0 - indicates no detection
1 - indicates detection

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

MASK

This attribute indicates if the PERSON is wearing the chemical protective mask.
Value:
0 - if the mask is not being worn (off)
1 - if the mask is being worn (on)

NAME

This attribute consists of an index number used to identify a particular PERSON.
Value: As given above

VEH.NO

This attribute consists of the index number used to identify the VEHICLE that the PERSON is on.
Value:
0 - The PERSON is not on a vehicle.
NUMBER(VEHICLE) that the PERSON is on, otherwise.

VEH.SYS.TYPE

This attribute, along with VEH.WPN.TYPE, is used to identify a particular vehicle type.
Value: As given above

VEH.WPN.TYPE

This attribute, along with VEH.SYS.TYPE, is used to identify a particular vehicle type.
Value: As given above

TEMPORARY ATTRIBUTES REAL

T.CHEMDET

This attribute stores the time at which the PERSON detected the presence of a persistent chemical agent hazard.

T.CP

This attribute provides the time at which the PERSON assumed his current level of collective protection.
Value: The time as given above

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

T.OHC

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.
Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)
The time as given above, if overhead cover exists.

X.CURRENT

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.
Value: As given above

Y.CURRENT

This attribute gives the Y coordinate of the location of the PERSON at the current simulation time, T.CURRENT.
Value: As given above

GLOBAL VARIABLES INTEGER

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

CLDCP

This variable gives the value for the most recent collective protection category that the PERSON was in, if he changed categories during DELT.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

VEH.PTR (1-D)

This array is used to store the pointer to the memory location where the temporary entity VEHICLE and its attributes are stored.

GLOBAL VARIABLES REAL

AG.DECAY

This array provides the amount of decay of each agent due to weathering that can be expected to occur in the interval DELT.
Dimensions: N.AGENT
Value: As given above, for each agent.

AGA.CUMDOSE (1-D)

This array holds the accumulated IV dosage for each agent.
Dimension: N.AGENT
Value: The dosage in mg accumulated up to the current time

CHANGE.ORDER (2-D)

This array is used to order changes in chemical protection external to the effects model. The array can be accessed by any routine by the name of each PERSON, and the changes in protection are ordered by changing the array values (they are initialized at -1 by the driver program).
Dimensions: N.PERSON by 10
Value:
1st dimension: The name of the PERSON
2nd dimension:
1 - Enter 1 if you want the PERSON to mask
2 - Enter the value of the new CP category if you want the PERSON to change his collective protection (values 1 - 5)
3 - Enter 1 if you want the PERSON to create temporary overhead cover
4 - Enter the value of the protection factor for a new item of clothing or gear to be put on over body area 1
5 - Same as above for body area 2
6 - Same as above for body area 3
7 - Same as above for body area 4

8 - Same as above for body area 5
9 - Same as above for body area 6
10 - Same as above for body area 7

D.PF.LEAK (3-D)

This array provides the probability distribution for determining the amount of leakage to liquid agents found in the items of protective clothing that cover the seven body areas.
Dimensions: 7 (the number of body areas) by 3
Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DEP.A.CURR (1-D)

This array holds the current values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.A.OLD (1-D)

This array holds the most recent values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.OLD (1-D)

This array holds the most recent values for the deposition on the ground at the location of the PERSON.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DT.PF (4-D)

This array holds the probability distribution used to determine the time required to don a given item of chemical protective clothing, for each body area.
Dimensions: N.SIDE by 3
Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

OLD.DOSE (1-D)

This array is used to store the values for the accumulated dosage as of end of the previous iteration.
Dimension: N.AGENT
Value: As given above

PC.PF.LEAK (2-D)

This array gives the probability that the item of full chemical protection covering a given body area will leak with respect to liquid agents.
Dimension: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The probability as given above for the body area 1 thru 7

PFA.CHEM (1-D)

This array provides the current protection factor for each of the seven body areas of the PERSON. Implicitly, this array also defines the current protective (MOPP) level.

PFA.LEAK (1-D)

This array provides the percentage leakage with respect to liquid agents of the chemical protective clothing on each of the seven body areas of the PERSON.
Dimension: 7
Values:
0 - If the item does not leak
A fraction between 0 and 1 if the item does leak

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TA.PF.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area. The pointer to this array is stored in the attribute T.PF.CHEM.

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES INTEGER

AG

This variable serves to pass the number of the agent concerned to another rouitne as an argument.
Value: AG = iteration counter j (current agent type)

RECURSIVE VARIABLES REAL

T.PF.D (1-D)

This variable is used to store the values of the time it takes to don each item of protective clothing (for each body area), as drawn from the distribution DT.PF.
Dimension: 7
Values: As drawn from DT.PF

U

This variable is used to store a random uniform (0,1) random number.

BRIEF EXPLANATION OF CODE

LINE 7

The variable T.CHEMCURR is initialized at TL in order to schedule changes in chemical protection later in the routine.

LINE 8

The variable OLDCP is initialized at the current CP category for this iteration of CHEM.CHEK.

LINES 10 - 12

The old accumulated dosage values are stored in the array OLD.DOSE, and the old ground and air deposition values are stored in the global arrays DEP.G.OLD and DEP.A.OLD.

LINES 14 - 16

The deposition at the current location of the PERSON is set at the current concentration (at z=0 meters for ground and z=2 meters for air) within the grid drawn by NUSSE II (or an equivalent model). In order to develop the code, a driver program called NUSSE II was written to simulate the output that might be obtained from a deposition & transport model. This routine has been included in the section on STAR implementation.

LINE 17

It is possible for the current NUSSE II value to be less than the previous value drawn at the last update if the individual is departing an area of contamination. Because the true value for the individual, rather than the terrain he is standing upon, will continue to be the amount of agent with which he was previously contaminated, the model sets the actual outside deposition DEP.G.CURR(j) for the jth agent at the maximum of the current NUSSE II deposition or the previous level DEP.G.OLD(j), adjusted for a decay factor AG.DECAY(j).

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LINES 19 - 22

The routine updates the attribute CHEM.DET by assigning it a value of one if the individual had a time of detection assigned during the last iteration.

LINES 23 - 70

The remaining lines schedule protective status changes ordered externally to the module. This is accomplished by changing values within the array CHANGE.ORDER. The routine first checks to make sure that the ordered change has not been previously implemented. If it had been, no changes are necessary.

LINES 23 - 27

If the first variable, CHANGE.ORDER(1) was set at one, the individual was directed to mask. As a result, the MASKING routine is called, the time of masking T.MASK is assigned a new value, and T.CHEMCURR updated to allow for scheduling of subsequent actions in UPDATE (if any).

LINES 28 - 36

Changes in collective protection category are considered next. The old CP value is stored in the variable OLDCP, the new CP is given the value in CHANGE.ORDER, the time is set to T.CHEMCURR, and CHANGE.ORDER is reinitialized to -1. If the change is to CP categories 1, 2, or 3, the overhead cover attribute (OHC) is adjusted as well.

LINES 37 - 41

The overhead cover can be changed separately from the CP when temporary overhead protection is ordered.

LINES 42 - 63

Changes the individual protection for any or all of the seven body areas ordered through the new level of protection specified in the CHANGE.ORDER subscripted variable. For each body area, a time to don the item of clothing is drawn from the array DT.PF and assigned to the recursive variable T.PF.D. The time at which the item was donned is assigned T.CHEMCURR + T.PF.D, and T.CHEMCURR is updated. Each body area is checked to see if

a leakage factor had been assigned previously. If it had not been (PFA.LEAK = 0), the possibility of leaking is evaluated by comparing a uniform random number against PC.PF.LEAK. If the item will leak, it is assigned a leakage factor in PFA.LEAK by drwaing from the distribution in D.PF.LEAK. If the PF in body area 2 was to be changed, MASKING is called to adjust the values for MASK and MASKLEAK. It will also set a value for T.MASK, but the masking time had previously been set in Line 48 (TA.PF.CHEM(2)). To correct for this, T.MASK is set equal to TA.PF.CHEM(2) (Line 59)

CODE

```
ROUTINE TO UPDATE   ''CHEM.CHECK
     PRINT  1 LINE THUS
ROUTINE UPDATE CALLED
     DEFINE T.PF.D AS A REAL, 1-DIMENSIONAL VARIABLE
     DEFINE AG AS AN INTEGER, 0-DIMENSIONAL VARIABLE
     RESERVE T.PF.D(*) AS 7
     RESERVE OLD.DOSE(*) AS N.AGENT      ''A GLOBAL VARIABLE TO STORE OLD
     LET T.CHEMCURR = TL                    ''DOSAGE INFORMATION
     LET OLDCP = CP(SOLDIER)
     FOR J=1 TO N.AGENT, DO
          LET DEP.G.OLD(J) = DEP.G.CURR(J)
          LET DEP.A.OLD(J) = DEP.A.CURR(J)
          LET OLD.DOSE(J) = AGA.CUMDOSE(J)
          LET AG = J
          CALL NUSSEIT GIVEN T.CURRENT, X.CURRENT(SOLDIER),
               Y.CURRENT(SOLDIER), AND AG
               YIELDING DEP.G.CURR(J) AND DEP.A.CURR(J)
          LET DEP.G.CURR(J) = MAX.F(DEP.G.CURR(J), DEP.G.OLD(J)*AG.DECAY(J))
     LOOP
     IF CHEMDET(SOLDIER) = 0          ''UPDATE CHEMICAL DETECTION STATUS
          THEN IF T.CHEMDET(SOLDIER) IS NOT EQUAL TO 0
               LET CHEMDET(SOLDIER) = 1
     REGARDLESS                        ''IMPLEMENT MOPP CHANGES IF ANY
     IF CHANGE.ORDER( NAME(SOLDIER), 1 ) = 1  ''ORDERED TO MASK
          THEN IF MASK(SOLDIER) IS NOT EQUAL TO 1
          CALL MASKING
          LET T.CHEMCURR = T.MASK(SOLDIER)
          LET CHANGE.ORDER( NAME(SOLDIER),1) = -1
     REGARDLESS IF CHANGE.ORDER( NAME(SOLDIER),2) IS GT 0
          THEN IF CP(SOLDIER) IS NE CHANGE.ORDER( NAME(SOLDIER),2)
          LET OLDCP= CP(SOLDIER)                ''ORDERED TO CHANGE CP
          LET CP(SOLDIER) = CHANGE.ORDER( NAME(SOLDIER),2)
          LET T.CP(SOLDIER) = T.CHEMCURR
          LET CHANGE.ORDER( NAME(SOLDIER),2) = -1
          IF CP EQUALS 4 OR CP EQUALS 5, LET T.OHC(SOLDIER) = 0
             ELSE LET T.OHC(SOLDIER) = T.CP(SOLDIER)
          REGARDLESS
     REGARDLESS IF CHANGE.ORDER( NAME(SOLDIER),3) = 1  ''CREATE OHC
          THEN IF T.OHC(SOLDIER) IS EQUAL TO 0 AND CP(SOLDIER) IS GT 3
          LET T.OHC(SOLDIER) = T.CHEMCURR
          LET CHANGE.ORDER( NAME(SOLDIER),3) = -1
     REGARDLESS
     ''REMAINING LINES ORDER CHANGES TO PF(1) THROUGH PF(7)
     FOR I=1 TO 7, DO
          LET J = I + 3
          IF CHANGE.ORDER( NAME(SOLDIER),J) IS GE 0
            THEN IF PFA.CHEM(I) IS NE CHANGE.ORDER(NAME(SOLDIER),J)
            LET T.PF.D(I) = DISTRIB( DT.PF VEH.SYS.TYPE,VEH.WPN.TYPE,I,*) )
            LET TA.PF.CHEM(I) = T.CHEMCURR + T.PF.D(I)
            LET PFA.CHEM(I) = CHANGE.ORDER( NAME(SOLDIER),J)
            IF PFA.LEAK(I) IS EQUAL TO 0
              LET U = DISTRIB( UPTR(*) )
              LIST U, PC.PF.LEAK(SIDE,I)
              THEN IF U IS LE PC.PF.LEAK(SIDE,I)
                 LET PFA.LEAK(I) = DISTRIB( D.PF.LEAK(SIDE,I,*) )
            REGARDLESS
            LET T.CHEMCURR = TA.PF.CHEM(I)
            IF I = 2 AND CHANGE.ORDER( NAME(SOLDIER),J) = 1     ''MASK DONNED
               CALL MASKING
               LET T.MASK(SOLDIER) = TA.PF.CHEM(I)
            REGARDLESS
            LET CHANGE.ORDER( NAME(SOLDIER),J) = -1
          REGARDLESS
     LOOP
     IF (CP(SOLDIER) IS GE 3) AND (T.CP(SOLDIER) IS GE TL)   ''LEFT VEHICLE
          REMOVE THIS SOLDIER FROM THE CREW( VEH.PTR(VEH.NO(SOLDIER)) )
          LET VEH.NO(SOLDIER) = 0
     REGARDLESS
''   LIST T.PF.D, TA.PF.CHEM, PFA.CHEM
     RETURN
END    ''OF ROUTINE UPDATE
```

3. The Routine MASKING

Purpose

1. Simulates donning of the protective mask.
2. Assigns the time that masking was complete to the attribute T.MASK, updates the attribute MASK and the array values PFA.CHEM(2) and TA.PF.CHEM(2).
3. Determines whether or not the mask will leak with respect to vapor; if it does, determines the amount of leakage and stores the value in the attribute MASKLEAK.
4. Determines whether or not the mask will leak with respect to liquid; if it will, determines the amount of leakage and stores the value in the array value PFA.LEAK(2).

TEMPORARY ATTRIBUTES INTEGER

MASK

This attribute indicates if the PERSON is wearing the chemical protective mask.
Value:
0 - if the mask is not being worn (off)
1 - if the mask is being worn (on)

MASKLEAK

This attribute indicates the amount of leakage (if any) that the mask will leak to vapors and aerosols. It is multiplied by the ouside concentration of agent at the PERSON's location, DEP.A.CURR, to yield the effective concentration of agent inside the mask. The value is drawn from the distribution D.MSKLEAK
Values:
0 - If the mask does not leak
A fraction between 0 and 1 if the mask does leak

NAME

This attribute consists of an index number used to identify a particular PERSON.
Value: As given above

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

GLOBAL VARIABLES INTEGER

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

D.MSKLEAK (2-D)

This array provides the probability distribution for the leakage of the protective mask.
Dimensions: N.SIDE by 3
Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

D.PF.LEAK (3-D)

This array provides the probability distribution for determining the amount of leakage to liquid agents found in the items of protective clothing that cover the seven body areas.
Dimensions: 7 (the number of body areas) by 3
Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.MASK (2-D)

This array holds the probability distribution used to determine the time required to don the protective mask.
Dimensions: N.SIDE by 3
Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

PC.MSKLEAK (1-D)

This array contains the probability that a protective mask will leak with respect to vapors and aerosols.
Dimension: N.SIDE
Values: The probability as given above

PC.PF.LEAK (2-D)

This array gives the probability that the item of full chemical protection covering a given body area will leak with respect to liquid agents.
Dimension: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The probability as given above for the body area 1 thru 7

PF.MAX (2-D)

This array provides the protection factor for the item that provides full chemical protection for a given body area. Implicitly, this array also defines the maximum protective (full MOPP) level.
Dimensions: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The protection factor for each body area, as explained above

PFA.CHEM (1-D)

This array provides the current protection factor for each of the seven body areas of the PERSON. Implicitly, this array also defines the current protective (MOPP) level.

PFA.LEAK (1-D)

This array provides the percentage leakage with respect to liquid agents of the chemical protective clothing on each of the seven body areas of the PERSON.
Dimension: 7
Values:
0 - If the item does not leak
A fraction between 0 and 1 if the item does leak

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

TA.PF.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area.

USTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES REAL

T.M.D

This variable is used to store the time that it takes to don the protective mask.

U

This variable is used to store a uniform (0,1) random number.

BRIEF EXPLANATION OF THE CODE

LINE 4

The routine determines the time it took this PERSON to don the mask by drawing from the global variable DT.MASK. The value drawn is assigned to the temporary variable T.M.D.

LINE 5

The attribute T.MASK, representing the time at which the donning process was completed, is set at the current simulation time for the individual, T.CHEMCURR, plus T.M.D.

LINES 6 - 7

Because the mask also provides protection to body area 2 from liquid chemical agent hazards, the value PFA.CHEM(2) is updated to show that added protection, and the time TA.PF.CHEM(2) is changed as well.

LINE 9

The attribute MASK is set at one, indicating that a protective mask is worn.

LINE 10

A check is made to see if the mask had been tagged as a leaker at some earlier time (MASKLEAK not equal to 0).

LINES 11 - 13

PC.MSKLEAK is compared to a uniform (0,1) number; if PC.MSKLEAK is greater than or equal to that number, the mask will leak.

LINE 14

The amount of leakage is set by accessing the D.MSKLEAK, and assigning the random number drawn from the distribution indicated by the array to the attribute MASKLEAK.

LINES 16 - 21

A check is made to see if the mask will leak with respect to liquid hazards. If the mask has not previously been tagged, the variable PC.PF.LEAK(2) is compared to a uniform (0,1) random number. If the mask will leak with respect to liquids, the value of PFA.LEAK(2) is drawn from the distribution D.PF.LEAK.

CODE

```
 1   ROUTINE FOR MASKING
 2        PRINT  1 LINE THUS
ROUTINE MASKING CALLED
 3        DEFINE T.M.D, U AS REAL VARIABLES
 4        LET T.M.D = DISTRIB( DT.MASK(SIDE,*) )          ''TIME IT TAKES TO MASK
 5        LET T.MASK(SOLDIER) = T.CHEMCURR + T.M.D
 6        LET TA.PF.CHEM(2) = T.MASK(SOLDIER)        ''ADJUSTING PF FOR FACE
 7        LET PFA.CHEM(2) = PF.MAX(SIDE,2)
 8        LIST T.M.D, T.MASK(SOLDIER), NAME(SOLDIER), PFA.CHEM(2),TA.PF.CHEM(2)
 9        LET MASK(SOLDIER) = 1
10        IF MASKLEAK(SOLDIER) IS EQUAL TO 0
11             LET U = DISTRIB( UPTR(*) )     ''UNIFORM(0,1) RANDOM NUMBER
12   LIST U, PC.MSKLEAK(SIDE)
13             THEN IF U IS LESS THAN PC.MSKLEAK(SIDE) ''THEN THE MASK WILL LEAK
14                  LET MASKLEAK(SOLDIER) = DISTRIB( D.MSKLEAK(SIDE,*) )
15        REGARDLESS
16        IF PFA.LEAK(2) IS NOT EQUAL TO 0, RETURN
17        OTHERWISE LET U = DISTRIB( UPTR(*) )     ''UNIFORM(0,1) RANDOM NUMBER
18   LIST U, PC.PF.LEAK(SIDE,2)
19        IF U IS LESS THAN PC.PF.LEAK(SIDE,2)  ''THEN MASK WILL ALLOW CONTAM.
20             LET PFA.LEAK(2) = DISTRIB( D.PF.LEAK(SIDE,2,*) )
21        REGARDLESS
22        RETURN
23   END        ''OF ROUTINE FOR MASKING
```

4. The Routine DETECTION

Purpose

1. Schedules, through assignment to the attribute T.CHEMDET, detection of a chemical agent hazard due to physical signs.
2. Schedules detection of a chemical agent hazard due to proximity to a chemical alarm or another PERSON that has previously detected the hazard.
3. Schedules injection of a nerve agent antidote upon detection of the hazard, if desired (this would be a wrongful injection based upon detection, not symptoms of nerve agent poisoning).
4. If detection occurs, calls the routines OHC, DECON and MOPP.

ROUTINES CALLED BY DETECTION

DECON
MASKING
MOPP
NAA
OHC

LABELS USED

EXIT
NEXT
OUT
PROXIMITY

TEMPORARY ATTRIBUTES INTEGER

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

MASK

This attribute indicates if the PERSON is wearing the chemical protective mask.
Value:
0 - if the mask is not being worn (off)
1 - if the mask is being worn (on)

T.CHEMDET

This attribute stores the time at which the PERSON detected the presence of a persistent chemical agent hazard. This detection may have occurred due to any of the four possible means of detection (see the DETECTION routine discussion in Chapter 3 for more detail).

WARNING

This attribute of an ALARM tells if the ALARM has sounded. The ALARM will automatically sound a warning when the concentration of agent in the air at the location of the ALARM passes the threshold concentration set for that alarm in the global variable AG.AL.THRESH.

TEMPORARY ATTRIBUTES REAL

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

X.ALARM

This attribute gives the X coordinate of the location of the ALARM at the current simulation time, T.CURRENT.
Value: As given above

Y.ALARM

This attribute gives the X coordinate of the location of the ALARM at the current simulation time, T.CURRENT.
Value: As given above

X.CURRENT

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.
Value: As given above

Y.CURRENT

This attribute gives the X coordinate of the location of the PERSON at the current simulation time, T.CURRENT.
Value: As given above

ALPTR (1-D)

This array is used to store the pointer to the memory location where the temporary entity ALARM and its attributes are stored.

CHEMSIT

This variable indicates the current situation facing the PERSON during this iteration. The value is determined by CHEM.CHECK at the beginning of the iteration over this PERSON.
Values:
0 - The PERSON is stationary and has not been directly attacked by (in the immediate effects ellipse of) a chemical agent munition
1 - The PERSON is in the immediate effects ellipse of a chemical agent munition. He may be stationary or moving
2 - The PERSON is moving in an area of previously deposited contamination. There is no airborne agent present
3 - The PERSON is moving in an area where there is still agent in the air (it has not all deposited on the ground), and has not been directly attacked by a chemical munition

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario. It is used to dimension all arrays dependent on the agent type, and set the value for all "DO LOOPS" that iterate over the agent type.
Value: As given above

N.ALARM

This variable gives the number of ALARMs created.
Value: As given above

N.PERSON

This variable gives the number of PERSONs created.
Value: As given above

PERSPTR (1-D)

This array is used to store the pointer to the memory location where the temporary entity PERSON and its attributes are stored.

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

AL.MAX.DIST (1-D)

This array holds the maximum distance from a PERSON to another PERSON or ALARM over which he would hear the alarm or notice the reaction of that other PERSON to a chemical hazard. Any PERSON or ALARM that has previously detected the presence of a chemical hazard will warn all other PERSONs within this distance of his position
Dimension: N.SIDE
Value: Derived from normal line-of-sight conditions and the expected distance that one could hear the standard alarm

DEP.A.CURR (1-D)

This array holds the current values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON. This information is supplied by NUSSE II or some equivalent model.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON. These values are supplied ny NUSSE II or some equivalent model
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DT.DETECT (5-D)

This array contains the probability distribution that is used to determine the glimpse

probability of detection, PT.CHEMDET, of a persistent chemical agent hazard, based on noticing physical signs, during the interval DELT. If PT.CHEMDET is greater than or equal to a uniform (0,1) random number, detection will have occurred during DELT. Because the variable PT.CHEMDET is a probability, only a uniform or deterministic distribution (with parameter(s) between 0 and 1) or a beta distribution can be used.
Dimensions: 4 by N.AGENT by 5 by 2 by 3
Values:
1st dimension: The chemical situation CHEMSIT + 1 (the +1 is to avoid having an index of zero)
2nd dimension: The agent present
3rd dimension: The collective protection category CP (1 thru 5)
4th dimension: The value of the attribute MASK + 1 (mask off or on)
5th dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

MIN.A.CHEM (1-D)

This array provides the minimum significant level of air concentration for each agent. If the concentration is below this value, it is treated as if there were no agent present.
Dimension: N.AGENT
Values: The minimum significant concentration for each agent

MIN.G.CHEM (1-D)

This array provides the minimum significant level of ground deposition for each agent. If the deposition is below this value, it is treated as if there were no agent present.
Dimension: N.AGENT
Values: The minimum significant deposition for each agent

PC.NAA (1-D)

This array contains the probability that the PERSON, as a result of poor training or panic, will inject himself with the nerve agent antidote under circumstances other than the appearence of nerve agent symptoms, such as detection of the agent or the appearence of symptoms caused by a chemicalagent other than the nerve agent.
Dimension: N.SIDE
Values: The probability as given above

PC.OHC (1-D)

This array contains the probability that a soldier that has detected the presence of a persistent agent hazard by any means will assume that the agent is still falling toward the ground, and as a result will seek overhead cover.
Dimension: N.SIDE
Values: The probability as given above

I.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES INTEGER

AG

This variable is used to pass the number of the agent concerned as an argument ot another routine.
Value: AG = The iteration counter j (the agent concerned)

NEARBY.DET

This variable is used to store the pointer to an entity - PERSON or ALARM - that is checked for proximity and detection status in the section of the routine labeled PROXIMITY.

RECURSIVE VARIABLES REAL

ALARM.DIST

This variable is used to store the distance to the PERSON or ALARM that is closest to the PERSON and has detected the presence of a persistent chemical agent. If the variable is less than AL.MAX.DIST + 1 at the end of the iteration over all PERSONs and ALARMs, then the PERSON has detected the agent.

DIST

This variable is used to store the distance to the current PERSON or ALARM being checked in the iteration over all PERSONs and ALARMs.

PT.CHEMDET

This variable represents the probability of detection during this iteration from the glimpse detection model. It is drawn from the array DT.DETECT.

U1; U2

These variables are used to store uniform (0,1) random numbers.

A BRIEF EXPLANATION OF CODE:

LINES 8 -9

Checks to see if there is any chemical agent present in the ground or in the air at the PERSONs location. If there is not agent present, then it is assumed that detection due to physical signs will not occur, and the routine moves down to the point where it begins to check for alarms or persons nearby (label PROXIMITY).

LINES 17 - 25

If there is agent present, then PT.CHEMDET is drawn from the array DT.DETECT. PT.CHEMDET represents the probability of detection during this iteration from the glimpse detection model. It is compared to a uniform (0,1) random number to determine if detection occurred during the last DELT seconds. If PT.CHEMDET is greater than or equal to the random number, T.CHEMDET is assigned the value shown if previously equal to zero. If

T.CHEMDET had been previously assigned a value due to another agent, it is given the earliest time (lines 23-24).

LINES 30 - 56

Determines if the PERSON will detect the presence of an agent based on a chemical agent alarm or by noticing a person nearby who has detected the agent. The rouitne will examine every ALARM and every other PERSON for proximity and detection status.

LINES 31; 46

Assigns th pointer to another PERSON or ALARM to the temporary variable NEARBY.DET.

LINES 33 - 36; 47 - 50

Computes the straight-line distance to NEARBY.DET.

LINES 37 - 42

Checks to see if NEARBY.DET is within the maximum alarm distance, AL.MAX.DIST, and if NEARBY.DET has detected previously. If so, assigns ALARM.DIST the distance to NEARBY.DET.

LINES 51 - 54

Checks to see if NEARBY.DET is within the maximum alarm distance, AL.MAX.DIST, and if NEARBY.DET (an alarm) has sounded the warning. If so, assigns ALARM.DIST the distance to NEARBY.DET.

LINES 58 - 64

If one or more PERSONs or ALARMs nearby has detected a chemical agent, ALARM.DIST will be less than or equal to the distance ALARM.DIST.MAX, so the PERSON being updated will have a time of detection T.CHEMDET assigned.

LINES 66 - 67

If he failed to detect the presence of a chemical hazard, the routine returns to CHEM.CHECK; otherwise, the current simulation time T.CHEMCURR is assigned the value for the PERSON's detection time, T.CHEMDET.

LINE 68

If the PERSON is inside a vehicle with overpressure (CP=1), the routine returns to CHEM.CHECK since it is assumed that soldiers inside closed vehicles with overpressure will not need to react to the detection event.

LINES 69 - 75

If the PERSON is not in a CP equal to 1, then a check is made to see if he is masked. If not, the mask routine is called and T.CHEMCURR is updated. If T.MASK had been assigned a value previously within DELT, it is integrated into the current event sequence by updating T.CHEMCURR to the value previously assigned to T.MASK.

LINES 76 - 80

Checks to see if the PERSON will inject a nerve agent antidote based on a panic reaction to the detection of the attack. If a uniform (0,1) random number is less than or equal to PC.NAA, then the NAA routine is called and injection will occur.

LINES 81 - 83

Since the PERSON at this point will have detected the presence of a chemical agent during the iteration (since he has not yet exited the routine), the DETECTION routine will call the routines OHC, DECON, and MOPP.

CODE

```
 1  ROUTINE FOR DETECTION ''OF CHEMICAL AGENTS
 2       PRINT  1 LINE THUS
DETECTION ROUTINE CALLED FROM MAIN
 3       DEFINE X, Y, ALARM.DIST, PT.CHEMDET AND DIST
 4           AS 0-DIMENSIONAL, REAL VARIABLES
 5       DEFINE NEARBY.DET, AG AS 0-DIMENSIONAL, INTEGER VARIABLES
 6       FOR J=1 TO N.AGENT, DO
 7           LET AG = J
 8           IF ( (DEP.G.CURR(J) IS GE MIN.G.CHEM(J)) OR (DEP.A.CURR(J)
 9               IS GE MIN.A.CHEM(J)) )    ''AGENT PRESENT AT LOCATION
10               LET PT.CHEMDET = DISTRIB( DT.DETECT( (CHEMSIT+1),
11                   AG, CP(SOLDIER), (MASK(SOLDIER)+1), * ) )
12       PRINT  1 LINE WITH
13       DT.DETECT((CHEMSIT+1),J,CP(SOLDIER),(MASK(SOLDIER)+1),1),
14       DT.DETECT((CHEMSIT+1),J,CP(SOLDIER),(MASK(SOLDIER)+1),2),
15       DT.DETECT((CHEMSIT+1),J,CP(SOLDIER),(MASK(SOLDIER)+1),3)
16       THUS
DT.DETECT CALLED: ****  ****  ****
17           LET U1 = DISTRIB( UPTR(*) )
18  LIST U1, PT.CHEMDET
```

```
        THEN IF U1 IS LE PT.CHEMDET      ''DETECTION HAS OCCURRED
            IF T.CHEMDET(SOLDIER) IS EQUAL TO 0
                LET T.CHEMDET(SOLDIER) = ( (1-PT.CHEMDET)*
                    (T.CURRENT-T.CHEMCURR) ) + T.CHEMCURR
            ELSE LET T.CHEMDET(SOLDIER) = MIN.F( T.CHEMDET(SOLDIER),
                 (((1-PT.CHEMDET)*(T.CURRENT-T.CHEMCURR)) + T.CHEMCURR) )
            ALWAYS
    REGARDLESS LOOP
LIST T.CHEMDET(SOLDIER)
'PROXIMITY' LET ALARM.DIST = AL.MAX.DIST(SIDE) + 1
PRINT  1 LINE THUS REACHED 'PROXIMITY' IN DETECTION ROUTINE
    FOR I = 1 TO N.PERSON, DO
        LET NEARBY.DET = PERSPTR(I)
        IF PERSPTR(I) = SOLDIER, GO EXIT
            OTHERWISE LET X = X.CURRENT(NEARBY.DET)
        LET Y = Y.CURRENT(NEARBY.DET)
        LET DIST = SQRT.F( (X-X.CURRENT(SOLDIER))**2 +
            (Y-Y.CURRENT(SOLDIER))**2 )
        IF DIST IS LESS THAN ALARM.DIST
''LIST NAME(NEARBY.DET), NAME(SOLDIER), X,Y,X.CURRENT,Y.CURRENT,DIST,
''T.CHEMDET(NEARBY.DET), TL
            THEN IF (T.CHEMDET(NEARBY.DET) IS LE TL) AND
                (T.CHEMDET(NEARBY.DET) IS NOT EQUAL TO 0)
                LET ALARM.DIST = DIST
        REGARDLESS
   'EXIT' LOOP
    FOR K = 1 TO N.ALARM, DO
        LET NEARBY.DET = ALPTR(I)
        LET X = X.ALARM(NEARBY.DET)
        LET Y = Y.ALARM(NEARBY.DET)
        LET DIST = SQRT.F( (X-X.CURRENT(SOLDIER))**2 +
            (Y-Y.CURRENT(SOLDIER))**2 )
        IF DIST IS LESS THAN ALARM.DIST
            THEN IF WARNING(NEARBY.DET) IS EQUAL TO 1
''LIST NEARBY.DET, WARNING(NEARBY.DET), DIST
                LET ALARM.DIST = DIST
        REGARDLESS
    LOOP
LIST ALARM.DIST, AL.MAX.DIST(SIDE)
    IF ALARM.DIST IS LE AL.MAX.DIST(SIDE)
        IF T.CHEMDET(SOLDIER) IS NOT EQUAL TO 0
            LET T.CHEMDET(SOLDIER) = MIN.F( T.CHEMDET(SOLDIER),
(((ALARM.DIST/AL.MAX.DIST(SIDE))*(T.CURRENT-T.CHEMCURR)) + T.CHEMCURR) )
            ELSE LET T.CHEMDET(SOLDIER) = (((ALARM.DIST/
                AL.MAX.DIST(SIDE))*(T.CURRENT-T.CHEMCURR)) + T.CHEMCURR)
    ALWAYS REGARDLESS
LIST T.CHEMDET(SOLDIER)
    IF T.CHEMDET(SOLDIER) = 0, GO OUT
    OTHERWISE LET T.CHEMCURR = T.CHEMDET(SOLDIER)
    IF CP(SOLDIER) = 1, GO OUT
    OTHERWISE IF MASK(SOLDIER) IS NOT EQUAL TO 1  ''NOT ALREADY MASKED
        CALL MASKING
        LET T.CHEMCURR = T.MASK(SOLDIER)
    REGARDLESS IF (TL IS LE T.MASK(SOLDIER)) AND (T.MASK(SOLDIER)
        IS LE T.CURRENT)
        LET T.CHEMCURR = T.MASK(SOLDIER)
    REGARDLESS
'NEXT' LET U2 = DISTRIB( UPTR(*) )
LIST PC.NAA, U2
    IF PC.NAA(SIDE) IS GE U2
        CALL NAA
    REGARDLESS
        CALL CHC GIVEN PC.OHC(SIDE)
        CALL DECON
        CALL MOPP
'OUT' RETURN
END     ''OF ROUTINE FOR DETECTION
```

5. <u>The Routine OHC</u>

Purpose:
1. If the PERSON is not already under overhead cover, decides if the PERSON will seek overhead cover inside a vehicle or bunker, create temporary overhead cover, or fail to assume overhead cover (thereby implicitly assuming that there is no persistent agent threat in the air)
2. If overhead cover is created or assumed, draws a time for this to be completed and assigns it to the attribute T.OHC.

ARGUMENTS

PROB REAL

This argument contains the probability that a soldier that has detected the presence of a persistent agent hazard by any means will assume that the agent is still falling toward the ground, and as a result will seek overhead cover.
Dimension: N.SIDE
Values: It is given the value contained in the variable PC.OHC for the side the PERSON is on, except when the routine is called from DECON2. In the latter case, is is given a value of one.

LABELS

A1
A2
A3
OUT

TEMPORARY ATTRIBUTES INTEGER

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

TEMPORARY ATTRIBUTES REAL

T.CP

This attribute provides the time at which the PERSON assumed his current level of collective protection.
Value: The time as given above

T.OHC

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.
Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)
The time as given above, if overhead cover exists.

GLOBAL VARIABLES INTEGER

CHEMSIT

This variable indicates the current situation facing the PERSON during this iteration. The value is determined by CHEM.CHECK at the beginning of the iteration over this PERSON.
Values:
0 - The PERSON is stationary and has not been directly attacked by (in the immediate effects ellipse of) a chemical agent munition
1 - The PERSON is in the immediate effects ellipse of a chemical agent munition. He may be stationary or moving
2 - The PERSON is moving in an area of previously deposited contamination. There is no airborne agent present
3 - The PERSON is moving in an area where there is still agent in the air (it has not all deposited on the ground), and has not been directly attacked by a chemical munition

OLDCP

This variable gives the value for the most recent collective protection category that the PERSON was in, if he changed categories during DELT. It is set equal to the current CP value at the beginning of the iteration by the routine UPDATE; if the CP category changes for any reason, the old category is

stored in OLDCP for the remainder of the iteration and the new CP category is stored in the attribute CP. It is used to accurately determine the reduction in concentration or deposition caused by the CP.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

DT.OHC (3-D)

This array holds the probability distribution used to determine the time required to reach or create overhead cover. The temporary variable T.OHC.D drawn from it is added to T.CHEMCURR to yield the time that the collective protection was reached (T.CP) or the time at which the overhead cover was completely over the body (T.OHC).
Dimensions: N.SIDE by 3
Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

PC.ACT.OHC (2-D)

This array provides the probabilities that an individual will choose a particular one of three alternative actions in seeking or creating overhead cover. A uniform (0,1) random number is drawn and compared first to the first element in the second dimension - If this number is less than that element of PC.ACT.OHC, the first action is chosen (enter a vehicle). If the number is greater than or equal to the first element, but less than the second element of the second dimension, the second action will be chosen (enter a bunker). Otherwise, the third action is chosen (create temporary overhead cover).
Dimensions: N.SIDE by 2

Values:
1st dimension: The number of the side the PERSON is on
2nd dimension:
1 - The probability of choosing action number 1
2 - The probaility of choosing action number 2, added to the first probability

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES REAL

T.OHC.D

This variable is assigned the value for the time it takes to seek or create overhead cover, as drawn from the distribution, D.OHC.

U1; U2

These variables are used to store uniform (0,1) random numbers.

BRIEF EXPLANATION OF CODE

LINES 5 - 6

Checks to see if the person is under overhead cover - T.OHC, the time that overhead cover was assumed, is not equal to zero, and/or the collective protection attribute CP is equal to 1, 2, or 3.

LINE 7

Checks to see if the PERSON is in CHEMSIT 2. Because this was defined as an area without ant airborne hazard, the liklihood of seeking overhead cover is virtually nil.

LINES 8 - 10

If the person is not presently under overhead cover, the probability that he will seek overhead cover, PROB, is compared to a random uniform (0,1) number as before. PROB is an argument passed to it by the calling routine. In all cases except when the OHC routine has been called by the routine DECON2, this variable will be equal to a global variable PC.OHC. PC.OHC is a user-supplied global variable that sets the probability that a PERSON who has been directly attacked by a chemical agent (CHEMSIT = 1) or is receiving indirect fire and is assuming it is a chemical agent, will assume that the threat posed is a persistent agent and that in doing so, will seek overhead cover.

LINES 11 - 16

PC.ACT.OHC, the N.SIDE X 2 array contains the probability of going into a vehicle (PC.ACT.OHC(SIDE,1)) and the probability of going into a bunker (PC.ACT.OHC(SIDE,2)) for each side. The probability of creating temporary overhead cover is one minus the sum of the other two. These probabilities are compared to a uniform (0,1) random number to determine the action that will be taken.

LINES 17 - 22; 23 - 28; 29 - 31

The time required to assume that overhead cover, given the action taken, is found from the N.SIDE X 3 X 3 array DT.OHC. The value drawn from DT.OHC is assigned to the temporary variable T.OHC.D, and T.CP, the time that the new CP category was assumed (when applicable) is T.OHC.D + T.CHEMCURR.

LINE 33

In all cases the time that temporary overhead cover was created, T.OHC, is T.OHC.D + T.CHEMCURR.

CODE

```
ROUTINE OHC GIVEN PROB
     DEFINE U1, U2, PROB AS 0-DIMENSIONAL, REAL VARIABLES
     PRINT 1 LINE WITH PROB THUS
ROUTINE OHC CALLED GIVEN *.**
LIST CHEMSIT, T.OHC(SOLDIER), CP(SOLDIER)
     IF T.OHC(SOLDIER) IS NOT EQUAL TO 0, RETURN  ''ALREADY UNDER OHC
     OTHERWISE IF CP(SOLDIER) IS LE 3, RETURN   ''UNDER OHC IN CP
     OTHERWISE IF CHEMSIT IS EQUAL TO 2, RETURN  ''CROSSING
     OTHERWISE LET U1 = DISTRIB( UPTR(*) )        ''A UNIF(0,1) RANDOM NO.
     LIST U1, PROB
     IF U1 IS GT PROB, RETURN   ''SOLDIER DOES NOT SEEK OHC
     OTHERWISE LET U2 = DISTRIB( UPTR(*) )
     LIST U2, PC.ACT.OHC
     IF U2 IS LT PC.ACT.OHC(SIDE,1), GO TO A1      ''A1 - GO TO VEHICLE
     OTHERWISE IF U2 IS LT PC.ACT.OHC(SIDE,2)
          GO TO A2                                 ''A2 - GO TO BUNKER
     OTHERWISE GO TO A3                            ''A3 - CREATE TEMP OHC
'A1' LET T.OHC.D = DISTRIB( DT.OHC(SIDE,1,*) )
     PRINT 1 LINE THUS
WENT TO ACTION A1 IN ROUTINE OHC
     LET OLDCP = CP(SOLDIER)
     LET CP(SOLDIER) = 2
     LET T.CP(SOLDIER) = T.CHEMCURR + T.OHC.D
     GO OUT
'A2' LET T.OHC.D = DISTRIB( DT.OHC(SIDE,2,*) )
     PRINT 1 LINE THUS
WENT TO ACTION A2 IN ROUTINE OHC
     LET OLDCP = CP(SOLDIER)
     LET CP(SOLDIER) = 3
     LET T.CP(SOLDIER) = T.CHEMCURR + T.OHC.D
     GO OUT
'A3' ''NOTE - OHC IS PROVIDED BY A1 AND A2, AS WELL AS A3
     PRINT 1 LINE THUS
WENT TO ACTION A3 IN ROUTINE OHC
     LET T.OHC.D = DISTRIB( DT.OHC(SIDE,3,*) )
'OUT'
     LET T.OHC(SOLDIER) = T.CHEMCURR + T.OHC.D
LIST T.OHC(SOLDIER), OLDCP, CP(SOLDIER), T.CP(SOLDIER)
RETURN
END     ''OF ROUTINE OHC
```

6. The Routine MOPP

Purpose:

1. Checks the levels of chemical protection stored in the array PFA.CHEM, for body areas 1 through 7, and compares them to the levels of maximum protection, PF.MAX.
2. If any of the levels of protection have associated times indicating that the donning of maximum chemical protection is scheduled (by other means, such as on order) but not yet completed (the time that donning the protection over area i was completed, TA.PF.CHEM(i), is after the current simulation time, T.CHEMCURR), then this scheduled donning is incorporated into the current MOPP sequence by assigning T.CHEMCURR the TA.PF.CHEM(i) value.
3. For areas of the body where the level of protection worn or scheduled to be worn is not the maximum level (full chemical protection), the routine draws the time it would take to don the item from the distribution array DT.PF, schedules the time that the donning would be complete, TA.PF.CHEM(i), updates the current time for that PERSON's activities, T.CHEMCURR, and assigns the maximum PF level to the appropriate PF.CHEM attribute.
4. Determines if each item of protective clothing or gear will leak; if it will, assigns a leakage factor to the array PFA.LEAK.

ROUTINES CALLED BY MOPP

MASKING

TEMPORARY ATTRIBUTES INTEGER

VEH.SYS.TYPE

This attribute, along with VEH.WPN.TYPE, is used to identify a particular vehicle type. Value: As given above

VEH.WPN.TYPE

This attribute, along with VEH.SYS.TYPE, is used to identify a particular vehicle type. Value: As given above

TEMPORARY ATTRIBUTES REAL

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

GLOBAL VARIABLES INTEGER

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

D.PF.LEAK (3-D)

This array provides the probability distribution for determining the amount of leakage to liquid agents found in the items of protective clothing that cover the seven body areas. The array elements PFA.LEAK are drawn from the distribution.
Dimensions: 7 (the number of body areas) by 3
Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.PF (4-D)

This array holds the probability distribution used to determine the time required to don a given item of chemical protective clothing, for each body area. The temporary variable T.PF.D is drawn from the distribution; when added to T.CHEMCURR, this yields the time at which the clothing was donned, TA.PF.CHEM(i) for body area i.
Dimensions: N.SIDE by 3
Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type

2 - The first parameter of the distribution
3 - The second parameter of the distribution

PC.PF.LEAK (2-D)

This array gives the probability that the item of full chemical protection covering a given body area will leak with respect to liquid agents. This leakage may be caused by tears, combat damage, improper fitting or donning, some agent being trapped under the garment from inadequate or no decontamination. If the item will leak, the leakage amount is drawn from D.PF.LEAK.
Dimension: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The probability as given above for the body area 1 thru 7

PF.MAX (2-D)

This array provides the protection factor for the item that provides full chemical protection for a given body area. Implicitly, this array also defines the maximum protective (full MOPP) level.
Dimensions: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The protection factor for each body area, as explained above

PFA.CHEM (1-D)

This array provides the current protection factor for each of the seven body areas of the PERSON. Implicitly, this array also defines the current protective (MOPP) level.

PFA.LEAK (1-D)

This array provides the percentage leakage with respect to liquid agents of the chemical protective clothing on each of the seven body areas of the PERSON. The leakage may be caused by tears, combat damage, improper fitting or donning, some agent being trapped under the garment from inadequate or no decontamination. The determination of whether or not the item would leak was accomplished through a comparison to PC.PF.LEAK. If the item will leak, the PFA.LEAK value is drawn from D.PF.LEAK.
Dimension: 7
Values:
0 - If the item does not leak

A fraction between 0 and 1 if the item does leak

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

TA.PF.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area. The pointer to this array is stored in the attribute T.PF.CHEM.

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES REAL

T.PF.D

This variable is used to store the time it takes to don an item of full chemical protective clothing (as defined by PF.MAX) over a given body area. It is drawn from the distribution DT.PF.

U

This variable is used to store a uniform (0,1) random number.

BRIEF EXPLANATION OF CODE:

LINE 5

If the PERSON is currently wearing an item of full chemical protection (e.g., the protective mask, which will protect body area 2), then the routine checks to see if the donning of this item has been completed or is scheduled to be completed at some time after the individual's current simulation time,

T.CHEMCURR. If the item has already been donned, then the routine will loop to the next body area in numerical order (which is also the logical donning order, by design).

LINE 6

For each area of the body which has not yet been afforded full protection, the routine enters the array DT.PF to obtain the appropriate distribution from which to draw the time it took to don that particular item of protective clothing, and assigns that value to T.PF.D.

LINES 7 - 9

The values in TA.PF.CHEM, PFA.CHEM, and T.CHEMCURR are updated.

LINES 10 - 12

If the protective mask was donned (body area 2), in addition to assigning values to TA.PF.CHEM(2), PFA.CHEM(2), and PFA.LEAK(2), the routine will update the values for T.MASK, MASK, and MASKLEAK by calling the MASKING routine. T.MASK will be the same time as TA.PF.CHEM(2), assigned in line 7.

LINES 14 - 18

If an item of protective clothing has been donned at this time, the routine will check to see if this item of gear will leak due to tears, combat damage, improper donning or fit, agent trapped under the clothing, etc. It does this by comparing a uniform (0,1) random number to the probability that a given item of full chemical protection over body area i will leak, PFA.LEAK(i). If it will, the amount of leakage, expressed as a percentage of the deposition on the outside of the garment, is drawn from the distribution D.PF.LEAK. This value is assigned to the array PFA.LEAK.

LINES 19 - 20

If the item is scheduled to be donned, then this scheduling is worked into the current schedule by assigning T.CHEMCURR the time at which that scheduled action will be completed, before moving on to the next body area.

LINE 24

If all items of the body have been protected, the routine will return to the calling routine. Note that T.CHEMCURR has been updated in cases where the individual has been scheduled, but has not yet completed, donning full protection.

CODE

```
 1   ROUTINE MOPP
 2        DEFINE T.PF.D, U AS 0-DIMENSIONAL, REAL VARIABLES
 3        PRINT  1 LINE THUS
ROUTINE MOPP CALLED
 4        FOR I = 1 TO 7, DO
 5            IF PFA.CHEM(I) IS NOT EQUAL TO PF.MAX(SIDE,I)
 6               LET T.PF.D = DISTRIB( DT.PF(VEH.SYS.TYPE, VEH.WPN.TYPE,I,*) )
 7               LET TA.PF.CHEM(I)  = T.CHEMCURR + T.PF.D
 8               LET T.CHEMCURR = TA.PF.CHEM(I)
 9               LET PFA.CHEM(I) = PF.MAX(SIDE,I)
10               IF I = 2             ''MASK DONNED
11                  CALL MASKING
12                  LET T.MASK(SOLDIER) = TA.PF.CHEM(2)
13               ELSE
14                  LET U = DISTRIB( UPTR(*) )
15                  LIST U, PC.PF.LEAK(SIDE,I), I
16                  IF U IS LE PC.PF.LEAK(SIDE,I)
17                     LET PFA.LEAK(I) = DISTRIB( D.PF.LEAK(SIDE,I,*) )
18               ALWAYS REGARDLESS
19            ELSE IF TA.PF.CHEM(I) IS GE T.CHEMCURR
20               LET T.CHEMCURR = TA.PF.CHEM(I)  ALWAYS
21            REGARDLESS LIST I, T.PF.D
22        LOOP
23        LIST TA.PF.CHEM, PFA.LEAK
24        RETURN
25   END      ''OF ROUTINE MOPP
```

7. The Routine DECON

Purpose:

1. Separates out the case of immediate decontamination after initial detection of the chemical agent hazard from the case of delayed decontamination after the appearance of symptoms of chemical agent poisoning.
2. For immediate decontamination:
   a. Determines if decontamination will occur using the parameter PC.IMM.DECON.
   b. If decontamination does not occur, checks to see if any body area with less than the maximum level of chemical protection was contaminated. If so, sets a PFA.LEAK value to account for agent trapped under the protective garment.
   c. If decontamination does occur, schedules decontamination of the skin first, then clothing second, through calls to routine DECON2. The time required to decontaminate multiple agents on the skin, if applicable, is added to the time required to decontaminate one agent using a multiplier AG.MULT.DECON.
3. For delayed decontamination:
   a. Schedules decontamination of all body areas through calls to DECON2.
   b. Adds the time required to remove items of protective clothing before decontaminating by doubling the donning time.
4. Determines if the protective mask will leak using the parameter PC.MSKLEAK. If it will, sets a value on the attribute MASKLEAK.
5. Calculates the total dose received during decontamination for each body area by calling the routine DECON2, then summing across all body areas to give the total dosage for each agent.
6. If the decontamination period extends beyond T.CURRENT, then the average dose that would be received during each DELT period from the current time (T.CHEMCURR) until the time decontamination is complete (T.DECON) and assigns this average DELT dose to the array AGA.DECON.DOSE whose pointer is stored in the attribute AG.DECON.DOSE.

ROUTINES CALLED BY DECON

DECON2
DEPOSITION

LABELS

DECON.NOW
DELAYED
OUT

TEMPORARY ATTRIBUTES REAL

MASKLEAK

This attribute indicates the amount of leakage (if any) that the mask will leak to vapors and aerosols. It is multiplied by the ouside concentration of agent at the PERSON's location, DEP.A.CURR, to yield the effective concentration of agent inside the mask. The value is drawn from the distribution D.MSKLEAK
Values:
0 - If the mask does not leak
A fraction between 0 and 1 if the mask does leak

T.DECON

This attribute gives the time at which the process of decontamination was completed, to include the donning of full chemical protection after decontamination.
Value: The time as given above

GLOBAL VARIABLES INTEGER

CHEMSIT

This variable indicates the current situation facing the PERSON during this iteration. The value is determined by CHEM.CHECK at the beginning of the iteration over this PERSON.
Values:
0 - The PERSON is stationary and has not been directly attacked by (in the immediate effects ellipse of) a chemical agent munition
1 - The PERSON is in the immediate effects ellipse of a chemical agent munition. He may be stationary or moving
2 - The PERSON is moving in an area of previously deposited contamination. There is no airborne agent present
3 - The PERSON is moving in an area where there is still agent in the air (it has not all deposited on the ground), and has not been directly attacked by a chemical munition

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

AGA.CUMDOSE (1-D)

This array holds the accumulated IV dosage for each agent.
Dimension: N.AGENT
Value: The dosage in mg accumulated up to the current time

AGA.DECON.DOSE (1-D)

This array holds the average dosage for each agent, in mg, that the PERSON will receive during each DELT interval while he is performing decontamination. It is used to increment the accumulated dosage array AGA.CUMDOSE for every DELT interval during which the PERSON is performing decontamination.
Dimension: N.AGENT
Value: A dosage in mg, which is the total dose received during decontamination divided by the number of DELT intervals it takes to perform the decontamination.

D.MSKLEAK (2-D)

This array provides the probability distribution for the leakage of the protective mask. The variable MASKLEAK, the percentage of leakage of the mask to vapors, is drawn from it using the function DISTRIB
Dimensions: N.SIDE by 3
Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

D.PF.LEAK (3-D)

This array provides the probability distribution for determining the amount of leakage to liquid agents found in the items of protective clothing that cover the seven body areas. The array elements PFA.LEAK are drawn from the distribution.
Dimensions: 7 (the number of body areas) by 3
Values:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DELT

The variable DELT is a user-supplied parameter that gives the time interval between iterations of CHEM.CHECK. It is reccommended that this interval be on the order of 10 seconds in length.

MIN.G.CHEM (1-D)

This array provides the minimum significant level of ground deposition for each agent. If the deposition is below this value, it is treated as if there were no agent present.
Dimension: N.AGENT
Values: The minimum significant deposition for each agent

PC.DEL.DECON (1-D)

This array provides the probabilities of choosing to decontaminate after symptoms of chemical agent poisoning have appeared. If decontamination is chosen, it will consist of removing all clothing and gear, decontaminating the entire body, and replacing the clothing with full chemical protective clothing. This option is offered when the routine DECON is called from the routine SYMPTOM.DETECT.
Dimension: N.SIDE
Values: The probability of performing delayed decontamination

PC.IMM.DECON (1-D)

This array provides the probabilities of choosing to decontaminate immediately after discovering the presence of a chemical agent hazard. This is prior to any verification that the hazard in fact does exist. If decontamination is chosen, it will consist of first decontaminating exposed skin, then any clothing that is not chemical protective. After decontamination has been completed, all

areas of the body will be covered by full chemical protective clothing. This option is offered when the routine DECON is called immediately after detection occurs.
Dimension: N.SIDE
Values: The probability of performing immediate decontamination

PC.MSKLEAK (1-D)

This array contains the probability that a protective mask will leak with respect to vapors and aerosols as a result of tears, combat damage, improper fitting or donning, etc. If the mask will leak, the leakage amount is drawn from D.MSKLEAK.
Dimension: N.SIDE
Values: The probability as given above

PC.PF.LEAK (2-D)

This array gives the probability that the item of full chemical protection covering a given body area will leak with respect to liquid agents. This leakage may be caused by tears, combat damage, improper fitting or donning, some agent being trapped under the garment from inadequate or no decontamination. If the item will leak, the leakage amount is drawn from D.PF.LEAK.
Dimension: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The probability as given above for the body area 1 thru 7

PF.MAX (2-D)

This array provides the protection factor for the item that provides full chemical protection for a given body area. Implicitly, this array also defines the maximum protective (full MOPP) level.
Dimensions: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The protection factor for each body area, as explained above

PFA.CHEM (1-D)

This array provides the current protection factor for each of the seven body areas of the PERSON. Implicitly, this array also defines the current protective (MOPP) level.

PFA.LEAK (1-D)

This array provides the percentage leakage with respect to liquid agents of the chemical protective clothing on each of the seven body areas of the PERSON. The leakage may be caused by tears, combat damage, improper fitting or donning, some agent being trapped under the garment from inadequate or no decontamination. The determination of whether or not the item would leak was accomplished through a comparison to PC.PF.LEAK. If the item will leak, the PFA.LEAK value is drawn from D.PF.LEAK.
Dimension: 7
Values:
0 - If the item does not leak
A fraction between 0 and 1 if the item does leak

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TA.PF.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area.

TA.IMPAIR (1-D)

This array provides the time at which the impairment dose threshold was reached for each agent.
Dimension: N.AGENT
Values:
0 - if the impairment dose threshold has not been met
The time as given above if the impairment dose threshold has been reached

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES INTEGER

AG

This variable is used to pass the agent type as an arguement to the routine DEPOSITION.
Value: AG = the iteration index j (the agent type under consideration)

BODY.AREA

This variable is used to pass the area of the body as an arguement to the routine DECON2.
Value: BODY.AREA = the iteration index i (the body area under consideration)

CONTAM

This variable is used as a flag to determine if there is agent present on the skin.
Values:
0 - if there is no contamination
1 - if there is contamination

FLAG

This variable is used as a flag to determine if symptoms have occurred as a result of the accumulated dosage for any agent. This is equivalent to checking to see if TA.IMPAIR(j) is not equal to zero for any agent type j.

RECURSIVE VARIABLES REAL

DECON.DOSE (1-D)

This array is used to accumulate the dosages accrued for each agent type j during the decontamination process, as computed in the routine DECON2. It is the sum over the body area i of all dosages (i,j).
Dimension: N.AGENT
Value: The sum over i of the array DOSE(i,j).

DEP (1-D)

This array is used to store the deposition on the ground and the concentration in the air of the agent type passed as an argument, at the time that decontamination commenced.
Dimension: 2
Value:
1 - The deposition for the agent on the ground.
2 - The concentration for the agent in the air (not used).

DEPOS (1-D)

This array is used to store the deposition of each agent type on the skin at the time that decontamination commenced. This information is passed back to the routine from the routine DEPOSITION in the first value of the vector DEPOS.
Dimension: N.AGENT
Value: The deposition for each agent as indicated above.

DCSE (2-D)

This array is used to store the incremental dosages received during the decontamination process, by agent and by body area.
Dimensions: 7 by N.AGENT
Values:
1st dimension: The body area concerned.
2nd dimension: The dosage received for each agent over the body area concerned.

DCSE2PASS (1-D)

This array is used an an argument to pass the dosages received for each agent over a given body area during the decontamination process. It is an arguement for the routine DECON2.
Dimension: N.AGENT
Values: The dosage of each agent received, as indicated above

T.PF.D

This variable is used as an argument to pass the time it took to don the item of chemical protective clothing over body area i from the routine DECON2. It is used in the delayed decontamination sequence to adjust for removal times.

TEMP

This variable is used as a temporary summation variable to sum the dosages in DOSE(i,j) over the index i (body area).

U1; U2; U3; U4

These variables are used to store uniform (0,1) random numbers.

A BRIEF EXPLANATION OF CODE:

LINES 12 - 19

The deposition on the PERSON is assumed to be the linearly interpolated value between his old deposition DEP.G.OLD and his current deposition DEP.G.CURR. This is found by calling the routine DEPOSITION with both the start and end times equal to the current simulation time T.CHEMCURR. CONTAM is used to indicate if an agent is present.

LINES 18; 22

The decision node between immediate and delayed decontamination is the array TA.IMPAIR. If TA.IMPAIR is not equal to zero for the agent concerned, then symptoms have appeared and delayed decontamination may be performed; otherwise, immediate decontamination may be performed. FLAG is used to determine if any TA.IMPAIR values are not equal to zero.

LINES 23; 77

When a person discovers that he has been traversing an area contaminated with a persistent chemical agent, he will decontaminate all exposed areas and don full protection. The probabilities are bypassed in this case since it is assumed that decontamination will occur.

LINES 24 - 27

If the PERSON has not shown symptoms, the probability of his assuming that the agent is persistent and that he is contaminated is expressed in the global variable PC.IMM.DECON. If he chooses to decontaminate, the routine proceeds to the label "DECON.NOW".

LINE 29

If he chooses not to decontaminate, then a check is made to see if he was, in fact, contaminated. If he wasn't, no action is required and the routine returns to the calling program.

LINES 30 - 34

If he was contaminated, then the values in the array PFA.LEAK are assigned positive values in all cases where his current protection factor for body area i (PFA.CHEM(i)) is not the protection factor belonging to the maximum chemical protection (PF.MAX(i)), reflecting the fact that he will have agent trapped under his protective garments when he chooses to don them.

LINES 36 - 53; 54 - 73

The exposed skin is decontaminated first by calling the routine DECON2. All areas that were not exposed skin (PF = 1) or fully protected (PF = PF.MAX) are decontaminated next through a call to routine DECON2.

LINES 39 - 40; 57 - 58

DECON2 serves as a subroutine to actually compute the decontamination times and dosages received during that time for each area of the body for all agents present on the skin.

LINES 41; 60; 84

The DECON2 routine returns the dose for the body area called for each agent. This is stored in a 2-dimensional array, DOSE(BODY.AREA,AGENT).

LINES 75 - 98

If the situation involved delayed decontamination, then all body areas are decontaminated regardless of the level of protection at the time decontamination is performed. The times to don the protective garment are doubled to reflect the time to remove the old protective item and decontaminate it, by adding the donning time to the variables T.CHEMCURR and TA.PF.CHEM.

LINES 42 - 46; 62 - 66; 87 - 91

If an item of protective clothing has been donned at this time, the routine will check to see if this item of gear will leak due to tears, combat damage, improper donning or fit, agent trapped under the clothing, etc. It does this by comparing a uniform (0,1) random number to the probability that a given item of full chemical protection over body area i will leak, PFA.LEAK(i). If it will,

the amount of leakage, expressed as a percentage of the deposition on the outside of the garment, is drawn from the distribution D.PF.LEAK. This value is assigned to the array PFA.LEAK.

LINES 47 - 52; 67 - 72; 91 - 96

If the protective mask was donned (body area 2), in addition to assigning values to TA.PF.CHEM(2), PFA.CHEM(2), and PFA.LEAK(2), the routine will update the values for T.MASK, MASK, and MASKLEAK by calling the MASKING routine. T.MASK will be the same time as TA.PF.CHEM(2).

LINES 101 - 110

Because the decontamination process is likely to stretch out over many iterations of CHEM.CHECK, and because the dosage received during the time that decontamination is in process is a function of the decontamination rate (the array DCR), the dosage received during the time of decontamination is computed by calling the routine DECON2.

LINES 101 - 105

The 2-dimensional array DOSE(i,j) is summed over the body area index i to give a whole-body dosage for each agent j.

LINES 106 - 108

If the decontamination process stretches out over more than one interval DELT, The average dose for each DELT period is computed and stored in the array AGA.DECON.DOSE. That array will be used to update the dosage in succeeding iterations until decontamination is complete.

LINE 109

If decontamination was completed befor T.CURRENT, the dosage accumulated is added to AGA.CUMDOSE. The remaining dosage received between T.DECON and T.CURRENT will be calculated in routines DOSE1 or DOSE3.

CODE

```
ROUTINE DECON
     PRINT 1 LINE THUS
ROUTINE DECON CALLED
     DEFINE I, AG, FLAG, BODY.AREA AND CONTAM AS 0-DIMENSIONAL,
          INTEGER VARIABLES
     DEFINE T.PF.D, U1,U2,U3,U4, TEMP AS 0-DIMENSIONAL, REAL VARIABLES
     DEFINE DECON.DOSE, DOSE2PASS, AND DEP AS 1-DIMENSIONAL, REAL ARRAYS
     DEFINE DOSE AS A 2-DIMENSIONAL, REAL ARRAY
     RESERVE DEP(*), DEPOS(*), DOSE2PASS(*), DECON.DOSE(*) AS N.AGENT
     RESERVE DOSE(*,*) AS 7 BY N.AGENT
     LET FLAG = 0
     LET CONTAM = 0
     FOR J = 1 TO N.AGENT, DO
         LET AG = J
        CALL DEPOSITION GIVEN T.CURRENT, T.CURRENT, AND AG
           YIELDING DEP(*)
        LET DEPOS(J) = DEP(1)
        IF DEPOS(J) IS GE MIN.G.CHEM(J), LET CONTAM = 1
        REGARDLESS IF TA.IMPAIR(J) IS NOT EQUAL TO 0, LET FLAG = 1
     REGARDLESS LOOP
 LIST DEPOS
 LIST FLAG
     IF FLAG IS EQUAL TO 1, GO TO DELAYED
     OTHERWISE IF CHEMSIT = 2, GO TO DECON.NOW
     OTHERWISE LET U1 = DISTRIB( UPTR(*) )
     LIST U1, PC.IMM.DECON(SIDE)
     IF U1 IS LE PC.IMM.DECON(SIDE), GO TO DECON.NOW
     OTHERWISE
 LIST CONTAM
     IF CONTAM IS NOT EQUAL TO 1, RETURN
     OTHERWISE FOR I = 1 TO 7, DO
        IF PFA.CHEM(I) IS NOT EQUAL TO PF.MAX(SIDE,I)
           LET PFA.LEAK(I) = DISTRIB( D.PF.LEAK(SIDE,I,*) )
     REGARDLESS LOOP
 RETURN
 'DECON.NOW' PRINT 1 LINE THUS
REACHED 'DECON.NOW' IN DECON ROUTINE
     FOR I = 1 TO 7, DO
        LET BODY.AREA = I
        IF PFA.CHEM(I) = 1
           CALL DECON2 GIVEN BODY.AREA AND DEPOS(*)
              YIELDING DOSE2PASS(*) AND T.PF.D
           FOR J = 1 TO N.AGENT, LET DOSE(I,J) = DOSE2PASS(J)
           LET U4 = DISTRIB( UPTR(*) )                  ''PF LEAK
           LIST U4, PC.PF.LEAK(SIDE,I), I
           IF U4 IS LE PC.PF.LEAK(SIDE,I)
              LET PFA.LEAK(I) = DISTRIB( D.PF.LEAK(SIDE,I,*) )
           REGARDLESS
           IF I = 2                                      ''MASK LEAK
             LET U3 = DISTRIB( UPTR(*) )
             LIST U3, PC.MSKLEAK(SIDE)
             THEN IF U3 IS LE PC.MSKLEAK(SIDE)
                LET MASKLEAK(SOLDIER) = DISTRIB( D.MSKLEAK(SIDE,*) )
           REGARDLESS
     REGARDLESS LOOP
     FOR I = 1 TO 7, DO
        LET BODY.AREA = I
        IF PFA.CHEM(I) IS NOT EQUAL TO PF.MAX(SIDE,I)
           CALL DECON2 GIVEN BODY.AREA AND DEPOS(*)
              YIELDING DOSE2PASS(*) AND T.PF.D
           FOR J = 1 TO N.AGENT, DO
              LET DOSE(I,J) = PFA.CHEM(I) * DOSE2PASS(J)
           LOOP
           LET U4 = DISTRIB( UPTR(*) )                  ''PF LEAK
           LIST U4, PC.PF.LEAK(SIDE,I)
           IF U4 IS LE PC.PF.LEAK(SIDE,I)
              LET PFA.LEAK(I) = DISTRIB( D.PF.LEAK(SIDE,I,*) )
           REGARDLESS
           IF I = 2                                      ''MASK LEAK
              LET U3 = DISTRIB( UPTR(*) )
              LIST U3, PC.MSKLEAK(SIDE)
              THEN IF U3 IS LE PC.MSKLEAK(SIDE)
                  LET MASKLEAK(SOLDIER) = DISTRIB( D.MSKLEAK(SIDE,*) )
           REGARDLESS
     REGARDLESS LOOP
     GO OUT
```

CODE

```
'DELAYED' PRINT  1 LINE THUS
REACHED 'DELAYED' IN DECON ROUTINE
     LET U2 = DISTRIB( UPTR(*) )
     IF CHEMSIT = 2, LET U2 = 0
     REGARDLESS LIST U2, PC.DEL.DECON(SIDE)
     IF U2 IS LE PC.DEL.DECON(SIDE)
          FOR I = 1 TO 7, DO
              LET BODY.AREA = I
              CALL DECON2 GIVEN BODY.AREA AND DEPOS(*)
                   YIELDING DOSE2PASS(*) AND T.PF.D
              FOR J = 1 TO N.AGENT, LET DOSE(I,J) = DOSE2PASS(J)
              LET TA.PF.CHEM(I) = T.CHEMCURR + T.PF.D
              LET T.CHEMCURR = T.CHEMCURR + T.PF.D
              LET U4 = DISTRIB( UPTR(*) )                  ''PF LEAK
              LIST U4, PC.PF.LEAK(SIDE,I)
              IF U4 IS LE PC.PF.LEAK(SIDE,I)
                   LET PFA.LEAK(I) = DISTRIB( D.PF.LEAK(SIDE,I,*) )
              REGARDLESS IF I = 2
                   LET U3 = DISTRIB( UPTR(*) )                  ''MASK LEAK
                   LIST U3, PC.MSKLEAK(SIDE)
                   THEN IF U3 IS LE PC.MSKLEAK(SIDE)
                        LET MASKLEAK(SOLDIER) = DISTRIB( D.MSKLEAK(SIDE,*) )
              REGARDLESS
          LOOP
     REGARDLESS
'OUT'  LET T.DECON(SOLDIER) = T.CHEMCURR
     LIST T.DECON(SOLDIER)
     FOR J=1 TO N.AGENT, DO
          LET TEMP = 0
          FOR I = 1 TO 7, LET TEMP = TEMP + DOSE(I,J)
          LET DECON.DOSE(J) = TEMP
LIST DECON.DOSE(J)
          IF T.DECON(SOLDIER) IS GT T.CURRENT
              LET AGA.DECON.DOSE(J) = DECON.DOSE(J)/
                   ((T.DECON(SOLDIER)-TL)/DELT)
          ELSE LET AGA.CUMDOSE(J) = AGA.CUMDOSE(J) + DECON.DOSE(J)
     REGARDLESS LOOP
RETURN
END     ''OF ROUTINE DECON
```

8. The Routine DECON2

Purpose:

1. Determines how many agents are present on the skin and clothing at the time of decontamination. The routine draws the time to decontaminate the first agent T.DECON.D from the array DT.DECON. If multiple agents are present, it will repeatedly multiply MULT.AG.DECON times T.DECON.D.
2. Computes the dosage received during decontamination for each agent present. In the case of crossing a contaminated area on foot where the PERSON remains standing prior to decontaminating, the dose is computed only over areas 5, 6, and 7
3. Schedules the donning of protective gear and assigns values to the array TA.PF.CHEM.

ARGUMENTS INTEGER

AREA

ARGUMENTS REAL

DEP (1-D)
DOSE2PASS (1-D)
T.PF.D

ROUTINES

DECON.DOSE
DISTRIB
OHC

LABELS

DCN
DOSECOMP
NEXT

TEMPORARY ATTRIBUTES INTEGER

CONTAMINATED

This attribute indicates if there is contamination over the entire surface of the PERSON or his collective protection
Values:
0 - No contamination over all surfaces
1 - Contamination present on all surfaces

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

DEFNUM

This attribute gives the relative defilade of the PERSON at any given time
Values:
1 - in a foxhole
2 - prone
3 - crawling
4 - kneeling or sitting
5 - standing

VEH.SYS.TYPE

This attribute, along with VEH.WPN.TYPE, is used to identify a particular vehicle type.
Value: As given above

VEH.WPN.TYPE

This attribute, along with VEH.SYS.TYPE, is used to identify a particular vehicle type.
Value: As given above

TEMPORARY ATTRIBUTES REAL

T.CHC

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.
Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)
The time as given above, if overhead cover exists.

GLOBAL VARIABLES INTEGER

CHEMSIT

This variable indicates the current situation facing the PERSON during this iteration. The value is determined by CHEM.CHECK at the beginning of the iteration over this PERSON.
Values:
0 - The PERSON is stationary and has not been directly attacked by (in the immediate effects ellipse of) a chemical agent munition
1 - The PERSON is in the immediate effects ellipse of a chemical agent munition. He may be stationary or moving
2 - The PERSON is moving in an area of previously deposited contamination. There is no airborne agent present
3 - The PERSON is moving in an area where there is still agent in the air (it has not all deposited on the ground), and has not been directly attacked by a chemical munition

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

DT.DECON (4-D)

This array provides a probability distribution from which the time it takes for emergency immediate decontamination of skin or clothing for each body area is drawn. This time does not include the time required to don protetive clothing after decontamination.

Dimensions: N.SIDE by N.AGENT by 7 body areas by 3
Values:
1st dimension: The side of the PERSON
2nd dimension: The agent concerned (in multiple agent situations, a factor MULT.AG.DECON will provide a way of adjusting the overall decontamination time)
3rd dimension: The body area concerned (1 through 7)
4th dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

DT.PF (4-D)

This array holds the probability distribution used to determine the time required to don a given item of chemical protective clothing, for each body area. The temporary variable T.PF.D is drawn from the distribution; when added to T.CHEMCURR, this yields the time at which the clothing was donned, TA.PF.CHEM(i) for body area i.
Dimensions: N.SIDE by 3
Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

MIN.G.CHEM (1-D)

This array provides the minimum significant level of ground deposition for each agent. If the deposition is below this value, it is treated as if there were no agent present.
Dimension: N.AGENT
Values: The minimum significant deposition for each agent

MULT.AG.DECON (1-D)

This array provides a means of adjusting the time it takes to decontaminate a given body area, T.DECON.D, drawn from DT.DECON, to allow for the presence of more than one agent on the skin. If there is a second agent present, T.DECON.D will be multiplied by MULT.AG.DECON to yield the time required to decontaminate both agents simulataneously. If there are three agents, T.DECON.D will be multiplied by MULT.AG.DECON twice; etc.
Dimension: N.AGENT

Value: The multiplication factor for that agent

PF.MAX (2-D)

This array provides the protection factor for the item that provides full chemical protection for a given body area. Implicitly, this array also defines the maximum protective (full MOPP) level.
Dimensions: N.SIDE by 7
Values:
1st dimension: The side that the PERSON is on
2nd dimension: The protection factor for each body area, as explained above

PFA.CHEM (1-D)

This array provides the current protection factor for each of the seven body areas of the PERSON. Implicitly, this array also defines the current protective (MOPP) level.

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

TA.PF.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area.

RECURSIVE VARIABLES INTEGER

AGENT

This variable is used to pass the agent type as an argument to the routine DECON.DOSE, an implementation routine written to perform the actual dosage calculations.
Value: AGENT = The iteration index j (the agent type).

FLAG

This variable is used as a flag to determine of there was any agent deposited on the skin at the time that decontamination commenced.

RECURSIVE VARIABLES REAL

DCSECPASS

This variable is used as an argument to pass the dose computed by the routine DECON.DOSE back to the calling routine.

T.DECON.D

This variable is used to store the time required to perform decontamination of a given body area for a single agent (or as adjusted by MULT.AG.DECON, for multiple agents).

BRIEF EXPLANATION OF CODE:

LINES 7 - 10

The calculation of the dosage received during decontamination assumes that the PERSON is under some type of cover prior to decontaminating so that he will receive no further contamination. In order to insure this, if overhead cover was not sought or created previously, the routine OHC is called with the probability of seeking overhead cover set at 1 (certainty).

LINES 12 - 19

Checks to see if there are multiple agents causing contamination (or any - it is possible for a person to suspect contamination where none is present). For the first agent, a time to both decontaminate the body area concerned is determined based on the array DT.DECON. The time to accomplish the decontamination of that body area, T.DECON.D, is added to T.CHEMCURR, the current simulation time. For multiple agents, MULT.AG.DECON multiplies T.DECON.D to increase the total time required to decontaminate.

LINES 20 - 26

If the body area is less than 5 and we are in the situation where the PERSON has been crossing a contaminated area (CHEMSIT = 2) on foot (CP = 5), is not contaminated (CONTAMINATED = 0), and has remained up until decontamination was begun (DEFNUM = 5), then no dosage is assessed. Otherwise, the dosage accumulated during the decontamination of that body area for each agent is computed in the sectioned labeled DOSECOMP.

LINES 28 - 34

The routine DECON.DOSE is called to compute the dosage received during decontamination for a given agent and body area (the body area was supplied as an argument to DECON2). The dose is returned by the arguement DOSECPASS, and the array for all agents is stored in a temporary variable DOSE2PASS, which is passed back to the routine DECON as an argument.

LINES 35 - 39

If decontamination was directed (called by the routine DECON) but there was no contamination present (FLAG = 0), decontamination is still performed and T.CHEMCURR is updated by a value T.DECON.D drawn from the distribution DT.DECON..No dosage is assessed.

LINES 41 - 47

After a body area has been decontaminated it is covered by a chemical protective garment with a protection factor value equal to PF.MAX (in other words, full chemical protection is assumed). To simulate this, a value T.PF.D representing the time it takes to don the standard item of protective gear for the body area concerned is drawn from the distribution DT.PF. This value is added to T.CHEMCURR to yield the time that the protection was donned, TA.PF.CHEM(i) (i = the body area) and then T.CHEMCURR is updated to this latest time. The level of protection for each item is changed to the level of full protection PF.MAX, as each item is donned.

CODE

```
ROUTINE DECON2 GIVEN AREA AND DEP YIELDING DOSE2PASS AND T.PF.D
     PRINT  1 LINE THUS
ROUTINE DECON2 CALLED
     DEFINE AREA, AGENT, J ,FLAG AS 0-DIMENSIONAL, INTEGER VARIABLES
     DEFINE T.DECON.D, T.PF.D, DOSECPASS AS 0-DIMENSIONAL, REAL VARIABLES
     DEFINE DEP, DOSE2PASS AS 1-DIMENSIONAL, REAL ARRAYS
     RESERVE DEP(*), DOSE2PASS(*) AS N.AGENT
     IF CP(SOLDIER) IS GE 4
         THEN IF T.CHC(SOLDIER) IS EQUAL TO 0
             CALL CHC GIVEN 1
     REGARDLESS
     LET FLAG = 0
     FOR J = 1 TO N.AGENT, DO
         IF DEP(J) IS GE MIN.G.CHEM(J)
             LET T.DECON.D = DISTRIB( DT.DECON(SIDE,J,AREA,*) )
             IF FLAG = 0
                 LET FLAG = 1
             ELSE LET T.DECON.D = MULT.AG.DECON(SIDE) * T.DECON.D
             REGARDLESS LET T.CHEMCURR = T.CHEMCURR + T.DECON.D
 LIST T.DECON.D, J, MULT.AG.DECON(SIDE)
             IF AREA IS LT 5
                 THEN IF CHEMSIT IS EQUAL TO 2
                    THEN IF CONTAMINATED(SOLDIER) IS EQUAL TO 0
                      THEN IF CP(SOLDIER) IS EQUAL TO 5
                          THEN IF DEFNUM(SOLDIER) IS EQUAL TO 5
                                LET DOSE2PASS(J) = 0
                                GO TO NEXT
             REGARDLESS
 'DOSECOMP' PRINT  1 LINE THUS
    REACHED 'DOSECOMP' IN ROUTINE DECON2
             LET AGENT = J
             CALL DECON.DOSE GIVEN AREA, AGENT, T.DECON.D, AND DEP(*)
                 YIELDING DOSECPASS
             LET DOSE2PASS(AGENT) = DOSECPASS
 LIST AREA, AGENT, DEP(AGENT), DOSE2PASS(AGENT), T.DECON.D
     REGARDLESS LOOP
 'NEXT' PRINT  1 LINE THUS
REACHED 'NEXT' IN ROUTINE DECON2
       IF FLAG = 0
          LET T.DECON.D = DISTRIB( DT.DECON(SIDE,1,AREA,*) )
          LET T.CHEMCURR = T.CHEMCURR + T.DECON.D
     REGARDLESS
 LIST T.DECON.D, AREA, T.CHEMCURR
 'DON' LET T.PF.D = DISTRIB( DT.PF(VEH.SYS.TYPE(SOLDIER),
          VEH.WPN.TYPE(SOLDIER),AREA,*) )
     LET TA.PF.CHEM(AREA) = T.CHEMCURR + T.PF.D
     LET T.CHEMCURR = TA.PF.CHEM(AREA)
     LET PFA.CHEM(AREA) = PF.MAX(SIDE,AREA)
 LIST T.PF.D, AREA, T.CHEMCURR
 RETURN
 END     ''OF ROUTINE DECON2
```

9. The Routine DEPOSITION

Purpose:

1. Computes the ground and air dosage at the given location of interest at any intermediate time within DELT using a linear approximation.
2. Adjusts the deposition received on the ground at the PERSON's location to the dosage received on the outer layer of the PERSON's clothing or skin based on the collective protection category, and the presence of overhead cover.

ARGUMENT INTEGER

AGENT

ARGUMENTS REAL

DEP (1-D)
T.END
T.START

SETS

CREW (1-D)

LABELS

BUNKER

TEMPORARY ATTRIBUTES INTEGER

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

OPEN.CLOSED

This VEHICLE attribute tells if the vehicle is open or closed. It is used to determine the leakage of agent into the vehicle, by setting an index in SW.NBC.FILTER
Value:
0 - if the vehicle is open

1 - if the vehicle is closed

VEH.NO

This attribute consists of the index number used to identify the VEHICLE that the PERSON is on.
Value:
0 - The PERSON is not on a vehicle.
NUMBER(VEHICLE) that the PERSON is on, otherwise.

VEH.SYS.TYPE

This attribute, along with VEH.WPN.TYPE, is used to identify a particular vehicle type.
Value: As given above

VEH.WPN.TYPE

This attribute, along with VEH.SYS.TYPE, is used to identify a particular vehicle type.
Value: As given above

TEMPORARY ATTRIBUTE REAL

T.OHC

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.
Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)
The time as given above, if overhead cover exists.

GLOBAL VARIABLES INTEGER

OLDCP

This variable gives the value for the most recent collective protection category that the PERSON was in, if he changed categories during DELT. It is set equal to the current CP value at the beginning of the iteration by the routine UPDATE; if the CP category changes for any reason, the old category is stored in OLDCP for the remainder of the iteration and the new CP category is stored in the attribute CP. It is used to accurately

determine the reduction in concentration or deposition caused by the CP.
Value: As given above

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

VEH.PTR (1-D)

This array is used to store the pointer to the memory location where the temporary entity VEHICLE and its attributes are stored.

GLOBAL VARIABLES REAL

DELT

The variable DELT is a user-supplied parameter that gives the time interval between iterations of CHEM.CHECK.

DEP.A.CURR (1-D)

This array holds the current values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.A.OLD (1-D)

This array holds the most recent values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.OLD (1-D)

This array holds the most recent values for the deposition on the ground at the location of the PERSON. This information was obtained during the last iteration of the model.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DEP.RED (3-D)

This array provides the conversion factor to convert the deposition of liquid agent or the concentration of airborne agent outside of the PERSON's collective protection to the effective concentration inside the protection or on the PERSON. It is multiplied by DEP.A.CURR (The first element in the last dimension) and by DEP.G.CURR (The second element) to yield the effective concentrations and depositions inside the collective protection, respectively. It is used only for CP categories 3, 4 and 5. (CP categories 1 and 2 are represented by SW.BREATHING).
Dimensions: N.AGENT by 3 by 2
Values:
1st dimension: The indices represent the various agents
2nd dimension: The indicices indicate the three non-vehicular degrees of collective protection. They are:
1 - Bunker or building (CP=3) or foxhole (CP=4) with temporary overhead cover (T.OHC not equal to zero)
2 - Foxhole with no overhead cover
3 - In the open (CP=5) with temporary overhead cover
3rd dimension:
1 - The fraction used to convert the air concentration
2 - The fraction used to conver the ground deposition

SW.NBC.FILTER (6-D)

This array provides the amount of leakage of agent through a vehicle, expressed as a percentage of the outside concentration. It is used to convert the concentration of agent in the air and deposition of agent on the exterior of the vehicle to an equivalent concentration and deposition inside the vehicle. The temporary variable PAX is used to store whether or not the PERSON is crew or passenger on the vehicle; the temporary variable HATCH is used to distinguish between a vehicle with overpressure working (CP=1), a vehicle without overpressure, closed, and either vehicle open (CP=2).
Dimensions: N.VEH.SYS.TYPE by N.VEH.WPN.TYPE by 2 by 3 by 2 by N.AGENT
Values:
1st dimension: The VEH.SYS.TYPE of the PERSON
2nd dimension: The VEH.WPN.TYPE of the PERSON
3rd dimension: PAX
PAX = 1 if PERSON belongs to a set CREW

PAX = 2 if the PERSON does not belong to a set CREW

4th dimension: HATCH

HATCH = 1 if CP = 1 (vehicle with operating overpressure system)

HATCH = 2 if CP = 2 and OPEN.CLOSED(VEHICLE) = 1 (vehicle without overpressure; closed

HATCH = 3 if OPEN.CLOSED(VEHICLE) = 0

5th dimension: State of agent

1 - for liquid agent

2 - for vapor or aerosol

6th dimension: The agent type

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

RECURSIVE VARIABLES INTEGER

HATCH

This variable is used to determine the index on the array SW.NBC.FILTER 4th dimension. It is set equal to one if the CP equals 1 (vehicle with operating overpressure system) It is set equalto two if the CP equals 2 and OPEN.CLOSED(VEHICLE) equals 1 (vehicle without overpressure; closed). It is set equal to 3 if OPEN.CLOSED(VEHICLE) equals 0.

PAX

This variable is used to determine the index on the array SW.NBC.FILTER 3rd dimension. It is set equal to one if the PERSON belongs to a set CREW. It is set equal to two if the PERSON does not belong to a set CREW.

RECURSIVE VARIABLES REAL

DEP.CURR (1-D)

This array is used to store the values for the ground deposition and air concentration at the location of the PERSON measured the time T.END.

Dimension: 2
Values:
1 - The ground deposition at time T.END.
2 - The air concentration at time T.END.

DEP.OLD (1-D)

This array is used to store the values for the ground deposition and air concentration at the location of the PERSON measured the time T.START.
Dimension: 2
Values:
1 - The ground deposition at time T.START.
2 - The air concentration at time T.START.

BRIEF EXPLANATION OF CODE:

LINES 7 - 9

These lines compute the starting deposition and concentration when the starting time argument (T.START) is equal to the starting time of the iteration (TL).

LINES 10 - 14

These lines compute the starting deposition and concentration when the starting time argument (T.START) is not the starting time of the iteration (TL).

LINES 15 - 17

These lines compute the final deposition and concentration when the final time argument (T.END) equals the ending time of the iteration (T.CURRENT).

LINES 18 - 21

These lines compute the final deposition and concentration when the final time argument (T.END) is not equal to the ending time of the iteration (T.CURRENT).

LINES 23 - 68

The routine next checks the collective protection category of the person by checking the global variable OLDCP. If the CP category is changed at any time during DELT, the old CP value is stored in this variable, and it will be updated to the new CP category before it is called a second time by DOSE2 or DOSE 3.

LINES 23 - 44

If the OLDCP value is one or two, the PERSON is inside a vehicle. The adjustment factors for vehicles are contained in a six-dimensional array SW.NBC.FILTER. The value contained in the array indicates the percentage of the outside dosage of agent that will penetrate into the vehicle. This value is multiplied by the average deposition and concentration over the interval of interest to yield the deposition and concentration used in dosage calculations. The temporary variables HATCH and PAX are used to set the 3rd and 4th indices of SW.NBC.FILTER.

LINES 45 - 50

If the OLDCP is three, the person is in a bunker. The array DEP.RED is used to calculate the reduction in deposition afforded by the bunker. The value in DEP.RED represents the percent of the unadjusted ground deposition will penetrate into the collective protection.

LINES 51 - 52

If the OLDCP is four (foxhole), a check is made to determine if the foxhole has temporary overhead cover (T.OHC not equal to zero, indicating the overhead cover has been assumed). If it has, it is assumed to provide the same degree of chemical protection as a bunker, and the dose is computed accordingly.

LINES 53 - 58

If there was no overhead cover, a different value from DEP.RED is multiplied by the average ground deposition to give the deposition on the PERSON in the foxhole.

LINES 59 - 64

If the OLDCP is not one, two, three, or four, it must be five which indicates that the PERSON is in the open. A check is made to see if temporary overhead cover has been assumed (T.OHC not equal to zero). If it has, the third index in the second dimension of DEP.RED is used to find the amount of agent that has penetrated under the cover.

LINES 65 - 68

If no cover has been assumed, no adjustment is made to the deposition - the deposition on the ground at the PERSON's location is assumed to be the same as that found on the PERSON, and the average of the old and current depositions will be used to find the dosage received.

CODE

```
 1  ROUTINE DEPOSITION GIVEN T.START, T.END, AND AGENT YIELDING DEP
 2       DEFINE T.START AND T.END AS 0-DIMENSIONAL, REAL VARIABLES
 3       DEFINE AGENT, HATCH, PAX AS 0-DIMENSIONAL, INTEGER VARIABLES
 4       DEFINE DEP, DEP.OLD, AND DEP.CURR AS 1-DIMENSIONAL, REAL VARIABLES
 5       PRINT 2 LINES WITH T.START, T.END, AND AGENT THUS
ROUTINE DEPOSITION CALLED GIVEN T.START = ***.***, T.END = ***.***
    AND AGENT = **
 6       RESERVE DEP(*), DEP.OLD(*), AND DEP.CURR(*) AS 2
 7       IF T.START IS EQUAL TO TL
 8           LET DEP.OLD(1) = DEP.G.OLD(AGENT)
 9           LET DEP.OLD(2) = DEP.A.OLD(AGENT)
10       ELSE LET DEP.OLD(1) = ((DEP.G.CURR(AGENT)-DEP.G.OLD(AGENT)) *
11           ((T.START-TL)/DELT)) + DEP.G.OLD(AGENT)
12           LET DEP.OLD(2) = ((DEP.A.CURR(AGENT)-DEP.A.OLD(AGENT)) *
13               ((T.START-TL)/DELT)) + DEP.A.OLD(AGENT)
14       REGARDLESS
15       IF T.END IS EQUAL TO T.CURRENT
16           LET DEP.CURR(1) = DEP.G.CURR(AGENT)
17           LET DEP.CURR(2) = DEP.A.CURR(AGENT)
18       ELSE LET DEP.CURR(1) = ((DEP.G.CURR(AGENT)-DEP.OLD(1)) *
19           ((T.END-T.START)/(T.CURRENT-T.START))) + DEP.OLD(1)
20           LET DEP.CURR(2) = ((DEP.A.CURR(AGENT)-DEP.OLD(2)) *
21               ((T.END-T.START)/(T.CURRENT-T.START))) + DEP.OLD(2)
22       REGARDLESS
23       IF (OLDCP = 1) OR (OLDCP = 2)
24           LET HATCH = 3
25           IF OPEN.CLOSED( VEH.PTR( VEH.NO(SOLDIER) ) ) = 1
26               IF OLDCP = 1
27                   LET HATCH = 1
28               ELSE LET HATCH = 2
29               REGARDLESS
30  LIST VEH.NO(SOLDIER),HATCH,OLDCP,OPEN.CLOSED( VEH.PTR( VEH.NO(SOLDIER) ))
31           REGARDLESS IF SOLDIER IS IN A CREW
32               LET PAX = 1
33           ELSE LET PAX = 2
34           REGARDLESS
35  LIST PAX
36           LET DEP(1) = ((DEP.CURR(1)+DEP.OLD(1))/2) *
37               SW.NBC.FILTER(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),
38                   PAX,HATCH,1,AGENT)
39           LET DEP(2) = ((DEP.CURR(2)+DEP.OLD(2))/2) *
40               SW.NBC.FILTER(VEH.SYS.TYPE(SOLDIER),VEH.WPN.TYPE(SOLDIER),
41                   PAX,HATCH,2,AGENT)
42           LET OLDCP = CP(SOLDIER)
43  ''LIST DEP
44           RETURN
45       OTHERWISE IF (OLDCP = 3)
46  'BUNKER' LET DEP(1) = ((DEP.CURR(1)+DEP.OLD(1))/2) * DEP.RED(AGENT,1,1)
47           LET DEP(2) = ((DEP.CURR(2)+DEP.OLD(2))/2) * DEP.RED(AGENT,1,2)
48           LET OLDCP = CP(SOLDIER)
49  ''LIST DEP
50           RETURN
51       OTHERWISE IF (OLDCP = 4)
52           IF T.OHC(SOLDIER) IS NOT EQUAL TO 0, GO TO BUNKER
53           OTHERWISE
54           LET DEP(1) = ((DEP.CURR(1)+DEP.OLD(1))/2) * DEP.RED(AGENT,2,1)
55           LET DEP(2) = ((DEP.CURR(2)+DEP.OLD(2))/2) * DEP.RED(AGENT,2,2)
56           LET OLDCP = CP(SOLDIER)
57  ''LIST DEP
58           RETURN
59       OTHERWISE IF T.CHC(SOLDIER) IS NOT EQUAL TO 0
60           LET DEP(1) = ((DEP.CURR(1)+DEP.OLD(1))/2) * DEP.RED(AGENT,3,1)
61           LET DEP(2) = ((DEP.CURR(2)+DEP.OLD(2))/2) * DEP.RED(AGENT,3,2)
62           LET OLDCP = CP(SOLDIER)
63  ''LIST DEP
64           RETURN
65       OTHERWISE LET DEP(1) = (DEP.CURR(1)+DEP.OLD(1))/2
66           LET DEP(2) = (DEP.CURR(2)+DEP.OLD(2))/2
67  ''LIST DEP
68           RETURN
69  END      ''OF ROUTINE DEPOSITION
```

10. The Routine DOSE1

Purpose:

1. It determines if there is any chemical agent present at the PERSON's location, either on the ground (and thus, on the PERSON if exposed) or in the air. If not, the routine exits to the calling program.
2. The routine computes the dose received during the previous DELT period of time, if not already computed. It does this by either computing the dose in the routine, or by calling the DOSE2 routine.

ROUTINES CALLED BY DOSE1

DOSE2

TEMPORARY ATTRIBUTES REAL

T.DECON

This attribute gives the time at which the process of decontamination was completed, to include the donning of full chemical protection after decontamination.
Value: The time as given above

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above.

GLOBAL VARIABLES INTEGER

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

AGA.CUMDOSE (1-D)

This array holds the accumulated IV dosage for each agent.
Dimension: N.AGENT
Value: The dosage in mg accumulated up to the current time

AGA.DECON.DOSE (1-D)

This array holds the average dosage for each agent, in mg, that the PERSON will receive during each DELT interval while he is performing decontamination. It is used to increment the accumulated dosage array AGA.CUMDOSE for every DELT interval during which the PERSON is performing decontamination. The DECON2 routine will compute this value.
Dimension: N.AGENT
Value: A dosage in mg, which is the total dose received during decontamination divided by the number of DELT intervals it takes to perform the decontamination.

DEP.A.CURR (1-D)

This array holds the current values for the concentration of agent(s) in the air (at a height of 2 meters) at the location of the PERSON.
Units: mg / cubic meter
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

MIN.A.CHEM (1-D)

This array provides the minimum significant level of air concentration for each agent. If the concentration is below this value, it is treated as if there were no agent present.
Dimension: N.AGENT
Values: The minimum significant concentration for each agent

MIN.G.CHEM (1-D)

This array provides the minimum significant level of ground deposition for each agent. If the deposition is below this value, it is treated as if there were no agent present.
Dimension: N.AGENT
Values: The minimum significant deposition for each agent

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TA.PF.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area.

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

RECURSIVE VARIABLE INTEGER

CONTAM

This variable serves as a flag to determine if there is any chemical agent present (on the ground or in the air) at the PERSON's location.

RECURSIVE VARIABLES REAL

T.INT

This variable serves to store the value of an intermediate time between T.OLD and T.CURRENT, if any.

T.OLD

This variable is used to store the value of the beginning of a time interval for dose computations. It is equal to TL is decontamination did not end during DELT; equal to T.DECON if decontamination did finish during DELT.

BRIEF EXPLANATION OF CODE:

LINES 5 - 9

The initial check provides a means of bypassing this routine in cases where the individual is not in an area of chemical hazard or contaminated as of the current time, T.CURRENT. If he is facing either a ground or airborne hazard, the routine must compute the dose received from that hazard.

LINES 10 - 13

Checks to see if decontamination was being performed in the DELT interval of interest, and has not yet been completed. If it was, the dose for the interval has been computed by the DECON routine, and the dose to be accumulated during DELT is stored in the array AGA.DECON.DOSE. The DOSE1 routine will update the accumulated dose by adding the amount in AGA.DECON.DOSE to the value contained in the array AGA.CUMDOSE for each agent.

LINES 14 - 15

Initializes T.OLD, T.INT

LINE 16

If decontamination had been completed during the last DELT seconds, the routine will adjust the dose computation for the period since decontamination was completed by setting the beginning of the interval over which the dose is to be computed, T.OLD, to the time decontamination was completed, T.DECON.

LINES 18 - 26

Checks to see if masking or donning of any individual items occurred during the DELT period of interest. If masking or donning an item had been completed during the DELT period, dosage calculations are performed at the old level of protection until the new level was completely assumed, then at the new level of protection. The variable T.INT is used to split up the interval into two; each with a different level of protection.

LINES 22 - 24

Checks to see if two or more events occurred during DELT; if they have, the dosage is first computed over the interval T.OLD to T.INT, then T.OLD is assigned the value T.INT so the remaining lines will compute the remaining dosage - that received after the original time T.INT.

LINES 23; 28; 29; 30

The routine calls the DOSE2 routine, which actually computes the dosage received during appropriate interval and assigns the cumulative dose to the array AGA.CUMDOSE for each agent. Both inhalation and percutaneous dosages are considered, and converted to an equivalent intravenous (IV) dose by DOSE2.

CODE

```
 1   ROUTINE DOSE1
 2        DEFINE T.OLD AND T.INT AS 0-DIMENSIONAL, REAL VARIABLES
 3        DEFINE CONTAM AS A 0-DIMENSIONAL, INTEGER VARIABLE
 4        PRINT 1 LINE THUS
ROUTINE DOSE1 CALLED
 5        FOR J = 1 TO N.AGENT, DO
 6            IF DEP.G.CURR(J) IS GE MIN.G.CHEM(J), LET CONTAM = 1
 7            REGARDLESS IF DEP.A.CURR(J) IS GE MIN.A.CHEM(J), LET CONTAM = 1
 8        REGARDLESS LOOP
 9        IF CONTAM = 0, RETURN
10        OTHERWISE IF T.DECON(SOLDIER) IS GT T.CURRENT,
11            FOR J = 1 TO N.AGENT, LET AGA.CUMDOSE(J) = AGA.CUMDOSE(J)
12                + AGA.DECON.DOSE(J)
13            RETURN
14        OTHERWISE LET T.INT = 0
15        LET T.OLD = TL
16        IF T.DECON(SOLDIER) IS GT TL, LET T.OLD = T.DECON(SOLDIER)
17        REGARDLESS
18        IF (T.MASK(SOLDIER) IS GT T.OLD)AND(T.MASK(SOLDIER) IS LT T.CURRENT)
19            LET T.INT = T.MASK(SOLDIER)
20        REGARDLESS FOR I = 1 TO 7, DO
21            IF (TA.PF.CHEM(I) IS GT T.OLD)AND(TA.PF.CHEM(I) IS LT T.CURRENT)
22                IF T.INT IS NOT EQUAL TO 0
23                    CALL DOSE2 GIVEN T.OLD AND T.INT
24                    LET T.OLD = T.INT
25                REGARDLESS LET T.INT = TA.PF.CHEM(I)
26        REGARDLESS LOOP
27        IF T.INT IS NOT EQUAL TO 0
28            CALL DOSE2 GIVEN T.OLD AND T.INT
29            CALL DOSE2 GIVEN T.INT AND T.CURRENT
30        ELSE CALL DOSE2 GIVEN T.OLD AND T.CURRENT
31        REGARDLESS
32        RETURN
33   END      ''OF ROUTINE DOSE1
```

11. The Routine DOSE2

Purpose:

The DOSE2 routine computes the dose received during the interval passed to it from the routine DOSE1 under each of the following circumstances:

1. No action was taken during the given interval that would have affected the PERSON's chemical protective status, or
2. The PERSON changed his collective protection status during DELT.

ARGUMENTS REAL

T.END
T.START

ROUTINES CALLED BY DOSE2

DEPOSITION
DOSE.COMPUTE

LABELS

OUT

TEMPORARY ATTRIBUTES REAL

T.CP

This attribute provides the time at which the PERSON assumed his current level of collective protection.

Value: The time as given above

T.OHC

This attribute provides the time at which the PERSON assumed his current level of collective protection, if he went into CP 1, 2, or 3 during this iteration; otherwise, it is the time that he created temporary overhead cover in CP 4 or 5. It is also used as a check to see if temporary overhead cover exists.

Value:
0 - if no overhead cover exists (or the PERSON is in CP 1, 2, or 3, where it automatically exists)

The time as given above, if overhead cover exists.

GLOBAL VARIABLES   INTEGER

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.

Value: As given above

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.

Value: SOLDIER = PERSPTR(NAME(PERSON))

BRIEF EXPLANATION OF THE CODE:

LINES 9 - 11

The routine first checks to see if the collective protection category (CP) changed during the interval passed to it (T.START to T.END) from the routine DOSE1. The DEPOSITION routine is called for the interval T.START to T.CP (the time that the collective protection category was changed).

LINE 12

The dosage is computed by calling the routine DOSE.COMPUTE, which is a routine that was written for the STAR implementation to perform the actual dosage computations.

LINES 13 - 15

The DEPOSITION routine is called again and the remaining dosage computed by calling the routine DOSE.COMPUTE for the interval T.CP to T.END.

LINES 17 - 25

Changes in the overhead cover category, indicated by a T.OHC (the time overhead cover was assumed) within the interval, are handled in an identical manner to lines 10 - 16 above.

LINES 26 - 28

If there had been no changes in protection status during the interval, the DEPOSITION routine is called for the entire interval T.START to T.END and the dosage is computed by calling the routine DOSE.COMPUTE for the entire interval.

CODE

```
 1   ROUTINE DOSE2 GIVEN T.START AND T.END
 2        DEFINE T.START AND T.END AS 0- DIMENSIONAL, REAL VARIABLES
 3        DEFINE AG AS A 0- DIMENSICNAL, INTEGER VARIABLE
 4        DEFINE DEF AS A 1-DIMENSIONAL, REAL ARRAY
 5        RESERVE DEP(*) AS 2
 6        PRINT  1 LINE WITH T.START AND T.END THUS
ROUTINE DOSE2 CALLED GIVEN  T.START = ***.*** , T.END = ***.***
 7        FOR J = 1 TO N.AGENT, DO
 8            LET AG = J
 9            IF(T.CP(SOLDIER) IS GT T.START) AND (T.CP(SOLDIER) IS LT T.END)
10               CALL DEPOSITION GIVEN T.START, T.CP(SOLDIER), AND AG
11                   YIELDING DEP(*)
12               CALL DOSE.COMPUTE GIVEN T.START, T.CP(SOLDIER), AG, AND DEP(*)
13               CALL DEPOSITION GIVEN T.CP(SOLDIER), T.END, AND AG
14                   YIELDING DEP(*)
15               CALL DOSE.COMPUTE GIVEN T.CP(SOLDIER), T.END, AG, AND DEP(*)
16               GO OUT
17            REGARDLESS IF(T.OHC(SOLDIER) IS GT T.START) AND (T.OHC(SOLDIER)
18               IS LT T.END)
19               CALL DEPOSITION GIVEN T.START, T.OHC(SOLDIER), AND AG
20                   YIELDING DEP(*)
21               CALL DOSE.COMPUTE GIVEN T.START, T.OHC(SOLDIER), AG, AND DEP(*)
22               CALL DEPOSITION GIVEN T.OHC(SOLDIER), T.END, AND AG
23                   YIELDING DEP(*)
24               CALL DOSE.COMPUTE GIVEN T.OHC(SOLDIER), T.END, AG, AND DEP(*)
25               GO OUT
26            REGARDLESS CALL DEPOSITION GIVEN T.START, T.END, AND AG
27               YIELDING DEP(*)
28            CALL DOSE.COMPUTE GIVEN T.START, T.END, AG, AND DEP(*)
29   'OUT'
30        LOOP
31        RETURN
32   END      ''OF ROUTINE DOSE2
```

12. The Routine CHEMCAS.EFFECTS

Purpose

1. Simulates the injection of the nerve agent antidote when symptoms of chemical agent poisoning appear, when presented with an actual nerve agent hazard, and when detection of any chemical agent hazard occurs.
2. Determines if the impairment dose threshold of the PERSON has been passed for each of the chemical agents, and assigns the time that the threshold has been reached to the array TA.INCAP, whose pointer is stored in the attribute T.AG.INCAP.
3. Calls the routine SYMPTOM.DETECT the first time that an impairment dose threshold is passed.
4. Determines if the incapacitation dose threshold of the PERSON has been passed for each of the chemical agents, and assigns the time that the threshold has been reached to the array TA.INCAP.
5. Determines if the lethal dose threshold has been passed for any agent. If it has, assigns a time of death through the attribute T.LETH.

ROUTINES CALLED BY CHEMCAS.EFFECTS

NAA
SYMPTOM.DETECT

LABELS

OUT

TEMPORARY ATTRIBUTES REAL

T.LETH

This attribute gives the time of death occuring as a result of an overdose of chemical agent. It is assigned the first time the dosage from any chemical agent passes its respective lethal dose threshold.
Value: The time as given above

T.NAA

This attribute stores the time at which the PERSON finished injecting himself with a nerve agent antidote.
Value: The time as given above

GLOBAL VARIABLES INTEGER

AGENT.TYPE (1-D)

This array is used to store an integer used to identify the type of agent. All nerve agents should be given a value of 1; other positive integers can be used to denote other types of agent. It is used to check the type of agent when the nerve agent antidote is injected; if the agent type is nerve, the dosage will be reduced by NAA.FACTOR; if the type is not nerve, then no dosage reduction will be applied.
Dimension: N.AGENT
Value:
1 - For nerve agents

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

AGA.CUMDOSE (1-D)

This array holds the accumulated IV dosage for each agent.
Dimension: N.AGENT
Value: The dosage in mg accumulated up to the current time

AGA.IMPAIR (1-D)

This array holds the impairment dose threshold values for each agent.
Dimension: N.AGENT
Value: As given above, for each agent

AGA.INCAP (1-D)

This array holds the incapacitation dose threshold values for each agent.
Dimension: N.AGENT
Value: As given above, for each agent

AGA.LETH (1-D)

This array holds the lethal dose threshold values for each agent.
Dimension: N.AGENT
Value: As given above, for each agent

DELT

The variable DELT is a user-supplied parameter that gives the time interval between iterations of CHEM.CHECK.

OLD.DOSE (1-D)

This array is used to store the values for the accumulated dosage as of end of the previous iteration. It is used to determine times at which impairment, incapacitation, or death occurred.
Dimension: N.AGENT
Value: As given above

PC.NAA (1-D)

This array contains the probability that the PERSON, as a result of poor training or panic, will inject himself with the nerve agent antidote under circumstances other than the appearence of nerve agent symptoms, such as detection of the agent or the appearence of symptoms caused by a chemical agent other than the nerve agent.
Dimension: N.SIDE
Values: The probability as given above

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

TA.IMPAIR (1-D)

This array provides the time at which the impairment dose threshold was reached for each agent.
Dimension: N.AGENT

Values:
0 - if the impairment dose threshold has not been met
The time as given above if the impairment dose threshold has been reached

TA.INCAP (1-D)

This array provides the time at which the incapacitation dose threshold was reached for each agent.
Dimension: N.AGENT
Values:
0 - if the incapacitation dose threshold has not been met
The time as given above if the incapacitation dose threshold has been reached

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

UPTR (1-D)

This array is used as a convenience to call for a uniform (0,1) random number.
Dimension: 3
Values:
1 - 2 (the uniform distribution)
2 - 0 (the first parameter)
3 - 1 (the second parameter)

RECURSIVE VARIABLES INTEGER

AGENT

This variable is used to store to value of the current agent type of interest.
Value: The iteration index j (the agent concerned).

FLAG1

This variable serves as a flag to determine if any impairment dose thresholds had been reached during previous iterations. If the value equals N.AGENT, then no impairment has occurred previous to this iteration.
Values:
N.AGENT - If no impairment had occurred as of the last iteration.
Any other value - if 1 or more impairment dose thresholds had previously been reached.

FLAG2

any impairment dose threshold had been met or exceeded during this iteration. If one (or more) had been, this variable also carries the agent type number of that agent (or the highest number if two or more agents pass the threshold during the same iteration of CHEM.CHECK).
Values:
0 - If no impairment dose threshold had been reached during this iteration.
The agent type number - if an agent had caused impairment during this iteration.

RECURSIVE VARIABLES REAL

U

This variable is used to store a uniform (0,1) random number.

BRIEF EXPLANATION OF CODE:

LINE 9

The routine begins by checking to see if the impairment dose threshold, found in the array AGA.IMPAIR, has been reached for any chemical agent.

LINES 10 - 14

When an impairment dose threshold is reached, a time of impairment is assigned to the array TA.IMPAIR.

LINES 15 - 17

If the agent causing the impairment is a nerve agent, then injection of an antidote will be performed. This is accomplished by calling the routine NAA.

LINES 18 - 22

If the nerve agent antidote has not previously been administered, then, when symptoms of a chemical agent appear, it is possible that the soldier, as a result of poor training or panic, may inject himself with the nerve agent antidote. This probability of this is contained in PC.NAA. If injection will occur, based on the comparison of a uniform (0,1) random number with PC.NAA, the routine NAA will be called.

LINES 25 - 28

If FLAG1 is equal to N.AGENT, and FLAG2 is equal to 0, than an impairment dose had been reached for the first time on this iteration. The routine SYMPTOM.DETECT is called to determine if the onset of impairment (causing the appearance of symptoms) will result in the scheduling of a detection (if a chemical hazard has not already been detected). If two or more agents cause impairment during the same DELT interval, the one with the highest number is arbitrarily used to call SYMPTOM.DETECT.

LINES 30 - 35

The routine next checks to see if the dose has reached the level of incapacitation for any agent. If it has, a time of incapacitation from that agent is assigned through the array TA.INCAP(i) for each agent i.

LINES 37 - 47

If the incapacitation dose has been passed for one or more agents, the routine checks to see if the lethal threshold has been reached. If it has, a time of death, T.LETH, is assigned as an attribute of the PERSON.

CODE

```
ROUTINE CHEMCAS.EFFECTS
     DEFINE FLAG1, FLAG2, AGENT AS 0-DIMENSIONAL, INTEGER VARIABLES
     DEFINE T.NAA.D, U AS 0-DIMENSIONAL, REAL VARIABLES
     PRINT  1 LINE THUS
ROUTINE CHEMCAS.EFFECTS CALLED
     LET FLAG1 = 0
     LET FLAG2 = 0
     FOR J = 1 TO N.AGENT, DO
         LET AGENT = J
         IF TA.IMPAIR(J) IS EQUAL TO 0, LET FLAG1 = FLAG1 + 1
             THEN IF AGA.CUMDOSE(J) IS GE AGA.IMPAIR(J)
                 LET FLAG2 = J
                 LET TA.IMPAIR(J) = ( (AGA.IMPAIR(J)-OLD.DOSE(J))/
                     (AGA.CUMDOSE(J)-OLD.DOSE(J)) *DELT ) + TL
                 LET T.CHEMCURR = TA.IMPAIR(J)
                 IF AGENT.TYPE(J) EQUALS 1           ''TYPE 1 IS NERVE AGENT
                     CALL NAA
                     GO OUT
                 REGARDLESS IF T.NAA(SOLDIER) = 0      ''NO NAA INJECTION
                     LET U = DISTRIB( UPTR(*) )        ''PREVIOUSLY
                     LIST U, PC.NAA(SIDE), AGENT
                     THEN IF U IS LE PC.NAA(SIDE), CALL NAA
                 REGARDLESS
'OUT' REGARDLESS LOOP
LIST FLAG1, FLAG2
     IF FLAG1 = N.AGENT              ''NO IMPAIR DOSE REACHED PREVIOUSLY
         IF FLAG2 = 0,  RETURN       ''NO IMPAIRMENT THIS ITERATION
         OTHERWISE CALL SYMPTOM.DETECT GIVEN FLAG2  ''IMPAIRMENT REACHED
     REGARDLESS                                      ''FOR FIRST TIME
     LET FLAG2 = 0
     FOR J = 1 TO N.AGENT, DO
         IF AGA.CUMDOSE(J) IS GT AGA.INCAP(J), LET FLAG2 = 1
             THEN IF TA.INCAP(J) IS EQUAL TO 0
                 LET TA.INCAP(J) = ( (AGA.INCAP(J)-OLD.DOSE(J))/
                     (AGA.CUMDOSE(J)-OLD.DOSE(J)) *DELT ) + TL
     REGARDLESS LOOP
     IF FLAG2 = 0, RETURN
     OTHERWISE FOR J = 1 TO N.AGENT, DO
         IF AGA.CUMDOSE(J) IS GE AGA.LETH(J)
             IF T.LETH(SOLDIER) IS NOT EQUAL TO 0
                 LET T.LETH(SOLDIER) = MIN.F( T.LETH(SOLDIER),
                     ( (AGA.INCAP(J)-OLD.DOSE(J))/
                     (AGA.CUMDOSE(J)-OLD.DOSE(J)) *DELT ) + TL   )
             ELSE LET T.LETH(SOLDIER) =
                     ( (AGA.INCAP(J)-OLD.DOSE(J))/
                     (AGA.CUMDOSE(J)-OLD.DOSE(J)) *DELT ) + TL
             REGARDLESS
     REGARDLESS LOOP
     RETURN
END     ''OF ROUTINE CHEMCAS.EFFECTS
```

13. The Routine SYMPTOM.DETECT

Purpose:

1. If the PERSON has not yet detected the presence of a chemical hazard, the routine schedules a detection at the impairment time of the first agent to cause impairment. The onset of impairment is assumed to be the time of the first appearance of noticeable symptoms.
2. Regardless of when detection occurred, the routine will call the routines MASK, OHC, DECON, and MOPP.

ARGUMENT INTEGER

AGENT

ROUTINES

DECON
MASKING
MOPP
OHC

TEMPORARY ATTRIBUTE INTEGER

MASK

This attribute indicates if the PERSON is wearing the chemical protective mask.
Value:
0 - if the mask is not being worn (off)
1 - if the mask is being worn (on)

TEMPORARY ATTRIBUTES REAL

T.CHEMDET

This attribute stores the time at which the PERSON detected the presence of a persistent chemical agent hazard. This detection may have occurred due to any of the four possible means of detection (see the DETECTION routine discussion in Chapter 3 for more detail).

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

GLOBAL VARIABLES INTEGER

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

PC.OHC (1-D)

This array contains the probability that a soldier that has detected the presence of a persistent agent hazard by any means will assume that the agent is still falling toward the ground, and as a result will seek over-head cover.
Dimension: N.SIDE
Values: The probability as given above

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

BRIEF EXPLANATION OF CODE:

LINES 4 - 6

The routine MASKING is called, forcing the PERSON to mask, if he has not already done so.

LINE 7

The time of detection of the presence of a persistent chemical agent, T.CHEMDET, is set equal to the latest value of the time of impairment (the value of T.CHEMCURR if not changed) or the time the mask was donned.

LINE 8

The individual may assume overhead cover, if necessary, so that he may decontaminate any exposed areas of the body. This is done by calling the routine OHC.

LINE 9

The DECON routine will be called, and the probability of delayed decontamination, contained in the global variable PC.DEL.DECON, will be used in the DECON routine.

LINE 10

The MOPP routine is called, causing the individual to don all items of chemical protective gear If decontamination had not been performed (which would have caused an increase in individual protection to full protection).

CODE

```
  1  ROUTINE SYMPTOM.DETECT GIVEN AGENT
  2       DEFINE AGENT AS A 0-DIMENSIONAL, INTEGER VARIABLE
  3       PRINT 1 LINE WITH AGENT THUS
 ROUTINE SYMPTOM.DETECT CALLED GIVEN **
  4       IF MASK(SOLDIER) IS NOT EQUAL TO 1
  5           PERFORM MASKING
  6           LET T.CHEMCURR = T.MASK(SOLDIER)
  7       REGARDLESS LET T.CHEMDET(SOLDIER) = T.CHEMCURR
  8       CALL OHC GIVEN PC.OHC(SIDE)
  9       CALL DECON
 10       CALL MOPP
 11       RETURN
 12  END      ''OF ROUTINE SYMPTOM.DETECT
```

14. The Routine NAA

Purpose:

1. Determines the time of the injection of the nerve agent antidote, and assigns that time to the attribute T.NAA.
2. Updates the array A.ANTIDOTE, assigning the value contained in the global variable NAA.FACTOR to the array elements corresponding to nerve agents.

TEMPORARY ATTRIBUTE   REAL

T.NAA

This attribute stores the time at which the PERSON finished injecting himself with a nerve agent antidote.
Value: The time as given above

GLOBAL VARIABLES   INTEGER

AGENT.TYPE   (1-D)

This array is used to store an integer used to identify the type of agent. All nerve agents should be given a value of 1; other positive integers can be used to denote other types of agent. It is used to check the type of agent when the nerve agent antidote is injected; if the agent type is nerve, the dosage will be reduced by NAA.FACTOR; if the type is not nerve, then no dosage reduction will be applied.
Dimension: N.AGENT
Value:
1 - For nerve agents

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SIDE

This variable is used to store the value of the side the PERSON is on. If the attribute COLOR is used, SIDE = COLOR(PERSON) + 1
Value: COLOR(PERSON) + 1

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.

Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

A.ANTIDOTE (1-D)

This variable is used to reduce the dosage for each agent by multiplying the accumulated dosage by the appropriate array element. It is initialized at 1 in the main (driver) program when the array is created. The pointer to the array is stored in the attribute ANTIDOTE. Currently, only the array elements corresponding to the nerve agents are modified - they are set equal to the value found in NAA.FACTOR by the routine NAA
Dimension: N.AGENT
Value: NAA.FACTOR for nerve agents; a suitable reduction factor for other agents.

DT.NAA (2-D)

This array holds the probability distribution used to determine the time required to inject the nerve agent antidote. The temporary variable T.NAA.D is drawn from the distribution and, when added to T.CHEMCURR, sets the time at which the injection was complete, T.NAA.
Dimensions: N.SIDE by 3
Values:
1st dimension: The side of the PERSON
2nd dimension:
1 - The distribution type
2 - The first parameter of the distribution
3 - The second parameter of the distribution

NAA.FACTOR (1-D)

This array provides the reduction factor used to reduce the effective intravenous dosage to account for the effect of a nerve agent antidote. The value is placed in the array A.ANTIDOTE when a nerve agent antidote is injected. When A.ANTIDOTE is multiplied by the current IV dosage contained in AGA.CUMDOSE, the nerve agent dosage will be reduced by the NAA.FACTOR.
Dimension: N.SIDE
Value: The reduction factor as given above

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

RECURSIVE VARIABLE REAL

T.NAA.D

This variable is used to store the time that it takes to inject a nerve agent antidote.

BRIEF EXPLANATION OF CODE:

LINE 4

The time it takes to administer the nerve agent antidote, T.NAA.D, is drawn from the array DT.NAA.

LINES 5 - 6

The result is added to the current simulation time for the individual, T.CHEMCURR. This completion time is also assigned to the attribute T.NAA.

LINES 7 - 10

The antidote is assumed to cause a reduction in the effective nerve agent dosage received by the PERSON, which can be expressed as a percentage of the actual dose absorbed. This percentage is contained in the variable NAA.FACTOR. Incorporation of this change in the dosage calculations is accomplished by changing the value in the array A.ANTIDOTE from its initial value of 1 to the value NAA.FACTOR for every agent whose type is nerve.

CODE

```
 1   ROUTINE NAA
 2        DEFINE T.NAA.D AS A 0-DIMENSIONAL, REAL VARIABLE
 3        PRINT  1 LINE THUS
ROUTINE NAA CALLED
 4        LET T.NAA.D = DISTRIB( DT.NAA(SIDE,*) )
 5        LET T.CHEMCURR = T.CHEMCURR + T.NAA.D
 6        LET T.NAA(SOLDIER) = T.CHEMCURR
 7        FOR J = 1 TO N.AGENT, DO
 8            IF AGENT.TYPE(J) = 1
 9                LET A.ANTIDOTE(J) = NAA.FACTOR(SIDE)
10        REGARDLESS LOOP
11   LIST T.NAA.D, T.CHEMCURR, T.NAA(SOLDIER),A.ANTIDOTE
12        RETURN
13   END     ''OF ROUTINE NAA
```

15. The Routine CROSSING

Purpose

1. Simulates the protective measures that would be taken by ground troops that encounter a chemical agent contamination hazard while moving.
2. Computes the dosage that would be received by troops crossing an area of prior deposition.
3. Handles all calculations in lieu of the routine CHEM.CHECK, once CHEM.CHECK has updated the situation and found that it involves crossing a previously contaminated area (any area with ground deposition but no agent in the air from primary deposition).

ROUTINES CALLED BY CROSSING

CHEMCAS.EFFECT
DETECTION
DOSE3

LABELS

DETECT
NEXT

TEMPORARY ATTRIBUTES INTEGER

CHEMDET

This attribute shows if the PERSON has detected the presence of a persistent chemical agent hazard as of the previous iteration of CHEM.CHECK.
Values:
0 - indicates no detection
1 - indicates detection

CONTAMINATED

This attribute indicates if there is contamination over the entire surface of the PERSON or his collective protection
Values:
0 - No contamination over all surfaces
1 - Contamination present on all surfaces

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:

1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

DEFNUM

This attribute gives the relative defilade of the PERSON at any given time
Values:
1 - in a foxhole
2 - prone
3 - crawling
4 - kneeling or sitting
5 - standing

TEMPORARY ATTRIBUTE REAL

T.CONTAM

This attribute gives the time at which contamination occurred over the entire surface of the PERSON or his collective protection.
Value: The time at which contamination occurred

GLOBAL VARIABLES INTEGER

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

DELT

The variable DELT is a user-supplied parameter that gives the time interval between iterations of CHEM.CHECK.

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.OLD (1-D)

This array holds the most recent values for the deposition on the ground at the location of the PERSON. This information was obtained during the last iteration of the model.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

MIN.G.CHEM (1-D)

This array provides the minimum significant level of ground deposition for each agent.
Dimension: N.AGENT

T.CHEMCURR

This variable serves as a counter that keeps track of the time at which the last action performed or scheduled to be performed by the PERSON was completed.

TI

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

BRIEF EXPLANATION OF CODE:

LINE 3

The first check the routine makes is to see if CHEMDET is equal to 1, indicating that the PERSON has detected the presence of a chemical agent hazard. If he has, then all reactive measures will have been scheduled through attribute assignments and the routine can go to the dosage computation section NEXT directly.

LINES 4 - 6

If the PERSON has not previously detected the presence of a chemical agent hazard, then the routine checks to see if the PERSON was in contamination previously (DEP.G.OLD not equal to zero for any agent). If he had not been, then he must have just entered an area of contamination and the beginning point for any chemical effects or actions, T.CHEMCURR, must be set at the time at which he first entered the contamination.

LINES 8 - 9

The time that the contaminated area was first entered, as given in equation 3.11 in Chapter 3, Section 5, is used to set T.CHEMCURR to indicate the beginning of the chemical crossing situation.

LINES 10 - 15

A check is made to see if the soldier should be tagged as contaminated. He will be so tagged if he is in a contaminated area, with the one exception of moving on foot - while he continues moving, he receives only contamination on his hands, legs and feet (see Chapter 3, Section 2 for more details).

LINE 16

The DETECTION routine is called.

LINE 17

The DOSE3 routine is called to compute the dose received while crossing.

LINE 18

The CHEMCAS.EFFECTS routine is called to assess the impact of the dosage recived during this iteration.

CODE

```
ROUTINE CROSSING
     PRINT  1 LINE THUS
ROUTINE CROSSING CALLED
     IF CHEMDET(SOLDIER) = 1, GO TO NEXT
     OTHERWISE FOR J = 1 TO N.AGENT, DO
         IF DEP.G.CLD(J) IS NOT EQUAL TO 0, GO TO DETECT
     REGARDLESS LOOP
     FOR J = 1 TO N.AGENT, DO
         IF DEP.G.CURR(J) IS GE MIN.G.CHEM(J)
             LET T.CHEMCURR = ( (MIN.G.CHEM(J)/DEP.G.CURR(J))*DELT ) + TL
             THEN IF CP IS NOT EQUAL TO 5
                 THEN IF DEFNUM IS NOT EQUAL TO 5
                     LET T.CONTAM(SOLDIER) = T.CHEMCURR
                     LET CONTAMINATED(SOLDIER) = 1
                     LIST T.CONTAM(SOLDIER), CONTAMINATED(SOLDIER), T.CHEMCURR
     REGARDLESS LOOP
'DETECT' PERFORM DETECTION
'NEXT' CALL DCSE3
     CALL CHEMCAS.EFFECTS
     RETURN
END     ''OF ROUTINE CROSSING
```

16. The Routine DOSE3

Purpose:

The DOSE3 routine computes the accumulated dose for each agent in situations where the PERSON is crossing an area of previous chemical contamination.

ROUTINES CALLED BY DOSE3

DEPOSITION
DOSE1
DOSE3.COMP

TEMPORARY ATTRIBUTES INTEGER

CP

This attribute indicates the current level of collective protection afforded the PERSON
Values:
1 - A vehicle with an operating overpressure system
2 - A vehicle without an overpressure system
3 - A bunker or building
4 - A foxhole, with or without temporary overhead cover
5 - No protection (the PERSON is in the open)

DEFNUM

This attribute gives the relative defilade of the PERSON at any given time
Values:
1 - in a foxhole
2 - prone
3 - crawling
4 - kneeling or sitting
5 - standing

TEMPORARY ATTRIBUTES REAL

T.DECON

This attribute gives the time at which the process of decontamination was completed, to include the donning of full chemical protection after decontamination.
Value: The time as given above

T.MASK

This attribute stores the time at which the PERSON finished donning his protective mask.
Value: The time as given above

GLOBAL VARIABLES INTEGER

N.AGENT

This variable gives the maximum number of agents that will be used in a given scenario.
Value: As given above

SOLDIER

This variable is used to conveniently refer to the memory location of the PERSON which is currently being checked in the model.
Value: SOLDIER = PERSPTR(NAME(PERSON))

GLOBAL VARIABLES REAL

AG.DECAY (1-D)

This array provides the amount of decay of each agent due to weathering that can be expected to occur in the interval DELT. It is multiplied by the deposition DEP.G.OLD at the beginning of the interval to yield the value at the end of the interval.
Dimensions: N.AGENT
Value: As given above, for each agent.

AG.PICKUP (1-D)

This array serves as a conversion factor to convert the deposition on the ground DEP.G.CURR in a contaminated area to the deposition that would be found on the surface of personnel and vehicles crossing that area - thus, it represents the percentage of the agent picked up in traversing a contaminated area.

Dimension: N.AGENT
Value: As given above, for each agent

AGA.CUMDOSE (1-D)

This array holds the accumulated IV dosage for each agent.
Dimension: N.AGENT
Value: The dosage in mg accumulated up to the current time

AGA.DECON.DOSE (1-D)

This array holds the average dosage for each agent, in mg, that the PERSON will receive

during each DELT interval while he is performing decontamination.

Dimension: N.AGENT
Value: A dosage in mg, which is the total dose received during decontamination divided by the number of DELT intervals it takes to perform the decontamination.

DEP.G.CURR (1-D)

This array holds the current values for the deposition on the ground at the location of the PERSON.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

DEP.G.OLD (1-D)

This array holds the most recent values for the deposition on the ground at the location of the PERSON. This information was obtained during the last iteration of the model.
Units: mg/ sq. cm
Dimension: N.AGENT
Values: As given above for each agent

T.CURRENT

This variable gives the current simulation time within the main combat model calling the chemical effects routines.
Value: The time as given above

TA.PP.CHEM (1-D)

This array provides the time that the current level of individual chemical protection was donned, for each body area.

TL

This variable gives the simulation time within the main combat model at the time of the last iteration.
Value: The time as given above

RECURSIVE VARIABLE INTEGER

AG

This variable is used pass the agent type of the agent concerned between this routine and

the DOSE3COMP routine, which is a routine written for the STAR implementation that does the actual computation of the dosages.
Value: The iteration index j (the agent concerned).

RECURSIVE VARIABLES REAL

DEP (1-D)

This array is used as an argument to pass the ground deposition and air concentration avveraged between the beginning and end of the time interval over which the dosage is to be computed.
Dimension: 2
Value:
1 - The average deposition on the ground.
2 - The average concentration in the air.

T.INT

This variable serves to store the value of an intermediate time between T.OLD and T.CURRENT, if any. It is used as an arguement to pass the beginning or end of a time interval to the routines DEPOSITION and DOSE3.COMP.

T.OLD

This variable is used to store the value of the beginning of a time interval for dose computations. It is equal to TL is decontamination did not end during DELT; equal to T.DECON if decontamination did finish during DELT. It is used as an arguement to pass the beginning of a time interval to the routines DEPOSITION and DOSE3.COMP.

BRIEF EXPLANATION OF CODE:

LINES 7 - 10

The routine begins by adjusting the exterior deposition DEP.G.CURR by the AG.PICKUP factor for all agents.

LINES 12 - 15

The next check made by the routine sees if the time that decontamination is complete is greater than or equal to the current time. If it is, then the dosage received has been computed with the DECON routine and so the DOSE3 calculations are not needed. The

routine will add the average dosage accumulated over DELT during decontamination, stored in the array AGA.DECON.DOSE, to the accumulated dosage value in array AGA.CUMDOSE, for each agent, then return to CROSSING.

LINES 16 - 19

The next check that is made is to see if the dosage calculations pertain to the one exceptional situation - a CP value and DEFNUM value of 5, indicating a PERSON crossing on foot, remaining upright. If the case is not exceptional, the normal dosage calculations apply, so the routine DOSE1 is called. Otherwise, the same general procedures as are used in DOSE1 are applied in the lines that follow, only dosage is only accumulated over the body areas 5, 6 and 7.

LINES 22 - 23

If decontamination had been completed during the last DELT seconds, the routine computes the dose since decontamination was completed by setting the beginning of the interval over which the dose is to be computed, T.OLD, to the time decontamination was completed, T.DECON.

LINES 26 - 36

Checks to see if masking or donning of any individual items occurred during the DELT period of interest. If masking or donning an item had been completed during the DELT period, dosage calculations are performed at the old level of protection until the new level was completely assumed, then at the new level of protection.

LINES 28 - 34

Checks to see if two or more events occurred during DELT; if they have, the dosage is first computed over the interval T.OLD to T.INT, then T.OLD is assigned the value T.INT so the remaining lines will compute the remaining dosage; that received after the original time T.INT.

LINES 32; 41; 43; 45

The routine calls the DOSE3.COMP routine, which actually computes the dosage received during appropriate interval and assigns the cumulative dose to the array AGA.CUMDOSE for

each agent. Both inhalation and percutaneous dosages are considered, and converted to an equivalent intravenous (IV) dose.

CODE

```
ROUTINE DOSE3
    DEFINE T.OLD, T.INT AS 0-DIMENSIONAL, REAL VARIABLES
    DEFINE AG AS A 0-DIMENSIONAL, INTEGER VARIABLE
    DEFINE DEP AS A 1-DIMENSIONAL, REAL ARRAY
    PRINT 1 LINE THUS
ROUTINE DOSE3 CALLED
    RESERVE DEP(*) AS N.AGENT
    FOR J = 1 TO N.AGENT, DO
      LET DEP.G.CURR(J) = MAX.F( DEP.G.CURR(J)*AG.PICKUP(J),
          DEP.G.OLD(J)*AG.DECAY(J) )
    LOOP
LIST DEP.G.CURR, AG.PICKUP, DEP.G.OLD, AG.DECAY
    IF T.DECON(SOLDIER) IS GT T.CURRENT,
      FOR J = 1 TO N.AGENT, LET AGA.CUMDOSE(J) = AGA.CUMDOSE(J)
        + AGA.DECON.DOSE(J)
      RETURN
    OTHERWISE IF (CP(SOLDIER) IS NOT EQUAL TO 5) OR
      (DEFNUM(SOLDIER) IS NOT EQUAL TO 5)
      CALL DOSE1
      RETURN
    OTHERWISE LET T.INT = 0
    LET T.OLD = TL
    IF T.DECON(SOLDIER) IS GT TL, LET T.OLD = T.DECON(SOLDIER)
    REGARDLESS
    IF (T.MASK(SOLDIER) IS GT T.OLD)AND(T.MASK(SOLDIER) IS LT T.CURRENT)
      LET T.INT = T.MASK(SOLDIER)
    REGARDLESS FOR I = 1 TO 7, DO
      IF (TA.PF.CHEM(I) IS GT T.OLD)AND(TA.PF.CHEM(I) IS LT T.CURRENT)
        IF T.INT IS NOT EQUAL TO 0
          FOR J = 1 TO N.AGENT, DO
          LET AG = J
          CALL DEPOSITION GIVEN T.OLD, T.INT AND AG YIELDING DEP(*)
          CALL DOSE3.COMP GIVEN T.OLD, T.INT, AG AND DEP(*)
          LOOP
          LET T.OLD = T.INT
        REGARDLESS LET T.INT = TA.PF.CHEM(I)
    REGARDLESS LOOP
    FOR J = 1 TO N.AGENT, DO
    LET AG = J
    IF T.INT IS NOT EQUAL TO 0
      CALL DEPOSITION GIVEN T.OLD, T.INT AND AG YIELDING DEP(*)
      CALL DOSE3.COMP GIVEN T.OLD, T.INT, AG AND DEP(*)
      CALL DEPOSITION GIVEN T.INT, T.CURRENT AND AG YIELDING DEP(*)
      CALL DOSE3.COMP GIVEN T.INT, T.CURRENT, AG AND DEP(*)
    ELSE CALL DEPOSITION GIVEN T.OLD, T.CURRENT AND AG YIELDING DEP(*)
    CALL DOSE3.COMP GIVEN T.OLD, T.CURRENT, AG AND DEP(*)
    REGARDLESS LOOP
    RETURN
END     ''OF ROUTINE DOSE3
```

APPENDIX D
IMPLEMENTATION IN STAR

A. ISSUES

1. Time of Implementation

Implementing a combat model intended to be a module within a high- resolution main combat simulation such as STAR is a long and involved process. There are many issues to be addressed to insure that the main combat simulation provides the input required by the model, the model provides the output desired to the main simulation, and the data structures and commands are compatable without errors such as multiply defined global variables, etc.

The first issue addressed is the time at which the chemical agent effects model is to begin operation. There are two possibilities: one choice is to create the entities at the beginning of the simulation run; input the variables,etc., and in general perform all the necessary housekeeping tasks required to place the module into operation at the beginning. The model can than be invoked immediately or at the point in the scenario, if known, where chemical agents are to be first employed. The alternative procedure is to slow down the simulation a bit at the moment the first appearence of chemical agents occurs; this reduces the memory and other requirements up front but forces scheduling many requirements at some point during the simulation.

The best approach depends on the scenario to be exercised. Given the relatively short real time lengths of scenarios exercised on STAR, four possible situations may occur. The first involves a non-chemical scenario. Although these are becoming increasingly less common as the emphasis

on integrating nuclear and chemical considerations into modelling has its effect on the scenarios developed, there are still many generally accepted scenarios used that do not involve chemical play. In this situation, implementation is moot.

A second possibility is modelling first use of chemicals, most likely at the outset of battle as part of the preparatory fires. This option may restrict chemical use to one side only, as reaction times may prevent retaliation in the first few hours of combat modelled. The module should be implemented at the onset, with the probabilities of treating artillery attacks as chemical attacks set low at the onset, and increased as the battle continues.

The third situation would involve modelling a battle at some point in time after chemicals have been initially employed. This will require immediate implementation of the model, with many if not all forces in high degrees of chemical protection and high probabilities of treating attacks as potentially chemical in nature.

The final possibility is the initiation of chemical play at some point after the battle has begun. In this instance, it may be desirable to implement to chemical effects model at the time that chemicals are introduced, rather than at the beginning of the simulation.

2. Tasks Required to Implement Model

There are two major tasks required to implement the model. First, the temporary entities PERSON and ALARM will need to be created. Currently, neither of those entities are considered outside of the chemical effects model and a nuclear damage assessment model under development. When these entities are created, the arrays whose pointers are stored as attributes must be reserved, and a few (such as AGA.IMPAIR and AGA.INCAP) must be initialized. The general

concept for creating these entities, as developed by LTC Kelleher, formerly Chief of the TRADOC Research Element, Monterey, and modified by the author, is to access each UNIT in the sets BLUE.ALIVE and RED.ALIVE and determine whether the unit has a crew. If it does, then those entities are created, and they are filed in the set CREW(UNIT). It is possible that a PERSON entity will represent the UNIT. If so, the initialization routine should create the PERSON nad store the entity pointer in the attribute HUMAN(UNIT). For each PERSON, the entity pointer of the UNIT is stored in the attribute ESSENCE(PERSON). The lethal dose threshold distribution is determined from the distribution D.LETH, and the global variables D.IMPAIR and D.INCAP are used to generate the impairment and incapacition dose thresholds, respectively. The UNIT's PLATOON should be accessed to determine the appropriate vector of protection factors to be implemented; these can be stored in the array CHANGE.ORDER whose pointer is stored in the attribute CHEM.CHANGE. The UPDATE routine will automatically update the protective status and assess leakage factors where appropriate. The X.CURRENT and Y.CURRENT attributes should be set at the UNIT's X.CURRENT, Y.CURRENT. The CP and DEFNUM of the PERSON should be determined from the current situation.

In addition to creating the entities, the global variables and attributes peculiar to the PERSON need to be read in. The user input requirements are given in Section B, below. Basically there are two types of input required. The first are the probabilities and probability distributions that drive the actions taken by the PERSONs modelled. The second type of input are the physical constants and characteristics pertaining to the chemical agents or PERSONs and ALARMs modelled.

3. Interfaces

There are several interfaces that need to be worked out between STAR and the chemical agent effects model. The first type is the inputs required by the model from STAR. The NUSSE II model, as modified to run on STAR, must be setup so that it can be called from the routine UPDATE and will provide a value for the ground deposition in mg / sq. cm and the air concentration at 2 meters in mg / cubic meter. A routine will need to be developed to figure out in which grid the PERSON is located, so the proper values can be accessed.

The means of placing information in the A.ROUND queue must be developed. Generally, whenever a PERSON is placed in a set VICTIM (which occurs whenever the PERSON is within the ellipse of effect), the time and nature of the round that initiated this placement should be added to the A.ROUND array at location RDPTR + 1, and then RDPTR must be incremented by 1.

A subroutine within the main model must be written to tie in CP and DEFNUM changes directed by the main simulation and the CP and DEFNUM attributes belonging to the PERSON. In addition, if the PERSON enters a vehicle, his VEH.NO attribute must reflect the NUMBER(VEHICLE) and he must be placed in the set CREW(VEHICLE). In addition, changes in the UNIT's X.CURRENT, Y.CURRENT must change the associated PERSON's attributes X.CURRENT, Y.CURRENT.

Other routines that should be added to effectively utilize the chemical effects model are discussed in Chapter 4. This model will not reach its full potential until these changes are realized.

B. COMPUTER ROUTINES FOR IMPLEMENTATION

1. Routines For Implementation

a. PREAMBLE

The PREAMBLE enclosed provides the definitions of all of the variables and entities used in the model. It should be appended to the PREAMBLE of the main simulation after a check for common variable names has been made.

b. MAIN (driver program)

The driver program used to test the routines independently has been included. The lines dealing with the creation of entities and the reservation and initialization of arrays should be ao particular interest.

c. USER1.INPUT

This routine was used to read in and echo all user-input varibles dealing with probabilities and probability distributions.

d. USER2.INPUT

This routine was used to read in and echo all user-input varibles dealing with physical constants and characteristics.

e. LIST.ATTRIBUTES

This routine was used to provide a printout of the arrays belonging to the PERSON that are stored in attribute pointers (listing the associated attributes simply provides a memory location number).

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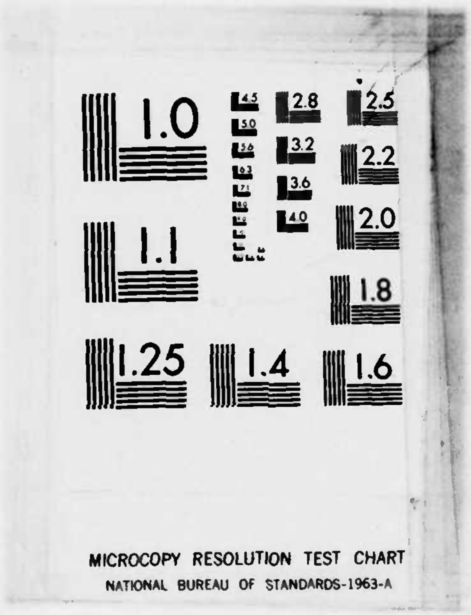
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

f. DISTRIB

This routine is used as a function to provide random numbers from a choice of six distributions: Deterministic, Uniform, Exponential, Normal, Lognormal, and Beta. It is called as: DISTRIB (Vector Pointer), where the vector is configured (Distribution type, 1st parameter, 2nd parameter). The routine uses random number input streams number 1; this may be changed if desired.

2. Routines For Debugging

a. NUSSEII

This routine was used to simulate the ground and air depositions and concentrations on a simple 20 x 20 grid (lower left-hand corner coordinate is the origin). This routine bears no resemblence to the real NUSSE II model but can be helpful in debugging routines without implementing the main model.

b. ARTILLERY.DRIVER

This routine was used to simulate two battery volleys - one conventional, one chemical, at a location near the PERSCN by providing input to the array A.ROUND and the attribute RDPTR(PERSCN).

3. Routine Codes

CODE

```
''*********    MASTER PROGRAM    *************
PREAMBLE
    NORMALLY, MODE IS REAL AND DIMENSION = 0
    GENERATE LIST ROUTINES
    TEMPORARY ENTITIES
        EVERY VEHICLE HAS A NUMBER AND AN OPEN.CLOSED AND OWNS A CREW
        EVERY ALARM HAS A WARNING, AN X.ALARM, AND A Y.ALARM
```

```
      EVERY PERSON HAS A DEP.GND, A DEP.AIR, A VEH.NO,
         A T.MASK, A T.CHEMDET, A MASK, A MASKLEAK, A DEFNUM,
         A CP, A T.OHC, A T.CP, A PF.CHEM, A PF.LEAK, A T.PF.CHEM,
         A CHEM.CHANGE, A T.AG.IMPAIR, A T.AG.INCAP, A T.LETH,
         A T.DECON, AN OLDX, AN OLDY, A CHEMDET, AN AG.DECON.DOSE,
         AN AG.CUMDOSE, AN AG.IMPAIR, AN AG.INCAP, AN AG.LETH,
         A COLOR, A VEH.SYS.TYPE, A VEH.WPN.TYPE, AN ESSENCE,
         A ROUND, A RDPTR, A CONTAMINATED, A T.CONTAM, AN ANTIDOTE,
         A T.NAA, AN X.CURRENT, A Y.CURRENT, AND A NAME
         AND MAY BELONG TO A CREW.
''VEHICLE ATTRIBUTES
   DEFINE NUMBER, OPEN.CLOSED AS INTEGER VARIABLES
''ALARM ATTRIBUTES
   DEFINE WARNING AS AN INTEGER VARIABLE
   DEFINE X.ALARM AND Y.ALARM AS VARIABLES
''ATTRIBUTES SERVING AS ARRAY POINTERS
   DEFINE DEP.GND, DEP.AIR, CHEM.CHANGE, T.AG.IMPAIR, T.AG.INCAP,
      AG.DECON.DOSE, AG.CUMDOSE, AG.IMPAIR, AG.INCAP, AG.LETH,
      T.PF.CHEM, PF.CHEM, PF.LEAK, ANTIDOTE, ROUND
      AS INTEGER VARIABLES
''ATTRIBUTES STORING INTEGER VALUES
   DEFINE CP, MASK, ESSENCE, CHEMDET, RDPTR, DEFNUM,
     COLOR, VEH.SYS.TYPE, VEH.WPN.TYPE, CONTAMINATED,
     VEH.NO, AND NAME AS INTEGER VARIABLES.
''ATTRIBUTES STORING TIMES OF ACTIONS TAKEN
   DEFINE T.MASK, T.CHEMDET, T.OHC, T.CP, T.DECON, T.CONTAM,
     T.NAA AS VARIABLES
''ATTRIBUTES STORING REAL VALUES
   DEFINE MASKLEAK, OLDX, OLDY, X.CURRENT, Y.CURRENT
   AS VARIABLES
''GLOBAL VARIABLES SUBSCRIPTED BY AGENT
   DEFINE DEP.G.OLD, DEP.A.OLD, AG.DECAY, OLD.DOSE, DCR,
     ABS, AG.INHAL.FACTOR, MIN.G.CHEM, MIN.A.CHEM, AG.PICKUP,
     D.IMPAIR, D.INCAP, AGENT.TYPE
     AS 1-DIMENSIONAL VARIABLES
''GLOBAL VARIABLES WITH DIFFERENT VALUES FOR EACH SIDE
''   AND SUBSCRIPTED BY BODY AREA OR AGENT
   DEFINE PF.MAX, AG.AL.THRESH, PC.PF.LEAK AND SKIN
     AS 2-DIMENSIONAL VARIABLES
''GLOBAL VARIABLES WITH DIFFERENT VALUES FOR EACH SIDE
   DEFINE PC.DEL.DECON, PC.NAA, PC.OHC,
     PC.MASK, PC.MSKLEAK, PC.MOPP, PC.IMM.DECON, AL.MAX.DIST,
     NAA.FACTOR, MULT.AG.DECON
     AS 1-DIMENSIONAL VARIABLES
''GLOBAL VARIABLES WITH DIFFERENT VALUES FOR EACH SIDE
''AND HAVING A SECOND DIMENSION
   DEFINE DT.MASK, DT.NAA AS 2-DIMENSIONAL VARIABLES
''GLOBAL TIME VARIABLES
   DEFINE T.CURRENT, TL, T.CHEMCURR, AND DELT AS VARIABLES
''ARRAYS WHOSE POINTERS ARE STORED AS ATTRIBUTES
   DEFINE DEP.G.CURR, DEP.A.CURR, PFA.CHEM, PFA.LEAK,
     TA.PF.CHEM, TA.INCAP, TA.IMPAIR, AGA.CUMDOSE, AGA.IMPAIR,
     AGA.INCAP, AGA.LETH, AGA.DECON.DOSE, A.ANTIDOTE
     AS 1-DIMENSIONAL VARIABLES
''OTHER DECLARATIONS
   DEFINE SOLDIER, OLDCP, CHEMSIT AND SIDE AS INTEGER VARIABLES
   DEFINE N.PERSON, N.VEH.SYS.TYPE, N.VEH.WPN.TYPE, N.VEHICLE,
     N.ALARM, N.SIDE AND N.AGENT AS INTEGER VARIABLES
   DEFINE DISTRIB AS A REAL FUNCTION
   DEFINE A.ROUND AS A 2-DIMENSIONAL ARRAY
   DEFINE VEH.PTR, ALPTR, PERSPTR AS 1-DIMENSIONAL, INTEGER ARRAYS
   DEFINE CHANGE.ORDER AS A 2-DIMENSIONAL ARRAY
   DEFINE D.LETH AS A 2-DIMENSIONAL ARRAY
   DEFINE DT.PF AS A 4-DIMENSIONAL ARRAY
   DEFINE DT.DETECT AS A 5-DIMENSIONAL ARRAY
   DEFINE PC.ACT.OHC AS A 2-DIMENSIONAL ARRAY
   DEFINE DT.OHC AS A 3-DIMENSIONAL ARRAY
   DEFINE DT.DECON AS A 4-DIMENSIONAL ARRAY
   DEFINE D.MSKLEAK AS A 2-DIMENSIONAL ARRAY
   DEFINE DEF.RED AS A 3-DIMENSIONAL ARRAY
   DEFINE D.PF.LEAK AS A 3-DIMENSIONAL ARRAY
   DEFINE UPTR AS A 1-DIMENSIONAL ARRAY
   DEFINE SW.BREATHING AS A 3-DIMENSIONAL ARRAY
   DEFINE SW.NBC.FILTER AS A 6-DIMENSIONAL ARRAY
END     ''OF PREAMBLE
```

CODE

```
MAIN
    DEFINE I,J,K,L,M AS 0-DIMENSIONAL, INTEGER VARIABLES
    READ N.VEHICLE, N.ALARM, N.PERSON, N.VEH.SYS.TYPE, N.VEH.WPN.TYPE,
        N.SIDE, N.AGENT
    LIST N.VEHICLE, N.ALARM, N.PERSON, N.VEH.SYS.TYPE, N.VEH.WPN.TYPE,
        N.SIDE, N.AGENT
    RESERVE VEH.PTR(*) AS N.VEHICLE
    RESERVE ALPTR(*) AS N.ALARM
    RESERVE PERSPTR(*) AS N.PERSON
    RESERVE UPTR(*) AS 3
    RESERVE DEP.G.OLD(*), DEP.A.OLD(*) AS N.AGENT
    RESERVE CHANGE.ORDER(*,*) AS N.PERSON BY 10
    RESERVE D.LETH(*,*) AS N.AGENT BY 3
    RESERVE D.IMPAIR(*), D.INCAP(*) AS N.AGENT
    RESERVE AGENT.TYPE(*) AS N.AGENT
    FOR I = 1 TO N.VEHICLE, DO
        CREATE A VEHICLE
        READ NUMBER(VEHICLE), OPEN.CLOSED(VEHICLE)
        LET VEH.PTR(NUMBER) = VEHICLE
        LIST ATTRIBUTES OF VEHICLE
    LOOP
    READ D.IMPAIR, D.INCAP, D.LETH
    LIST D.IMPAIR, D.INCAP, D.LETH
    FOR I = 1 TO N.ALARM, DO
        CREATE AN ALARM
        READ X.ALARM(ALARM), Y.ALARM(ALARM)
        LET ALPTR(I) = ALARM
        LIST ATTRIBUTES OF ALARM
    LOOP
    FOR I=1 TO N.PERSON, DO
        CREATE A PERSON
        READ NAME(PERSON), MASK(PERSON)
        RESERVE PFA.CHEM(*) AS 7
        FOR J = 1 TO 7, READ PFA.CHEM(J)
        READ CP(PERSON), VEH.SYS.TYPE(PERSON),
            VEH.WPN.TYPE(PERSON), COLOR(PERSON), X.CURRENT(PERSON),
           Y.CURRENT(PERSON), AND VEH.NO(PERSON)
        LET PERSPTR(NAME) = PERSON
        IF VEH.NO(PERSON) IS NCT EQUAL TO 0
            FILE PERSON IN CREW(VEH.PTR(VEH.NO))
        REGARDLESS
        LET CHEM.CHANGE(PERSON) = CHANGE.ORDER(NAME,*)
        FOR K = 1 TO 10, LET CHANGE.ORDER(NAME,K) = -1    ''INITIALIZE
        RESERVE DEP.G.CURR(*) AS N.AGENT
        LET DEP.GND(PERSON) = DEP.G.CURR(*)
        LET DEP.G.CURR(*) = 0
        RESERVE DEP.A.CURR(*) AS N.AGENT
        LET DEP.AIR(PERSON) = DEP.A.CURR(*)
        LET DEP.A.CURR(*) = 0
        LET PF.CHEM(PERSON) = PFA.CHEM(*)
        LET PFA.CHEM(*) = 0
        RESERVE PFA.LEAK(*) AS 7
        LET PF.LEAK(PERSON) = PFA.LEAK(*)
        LET PFA.LEAK(*) = 0
        RESERVE TA.PF.CHEM(*) AS 7
        LET T.PF.CHEM(PERSON) = TA.PP.CHEM(*)
        LET TA.PF.CHEM(*) = 0
        RESERVE TA.IMPAIR(*) AS N.AGENT
        LET T.AG.IMPAIR(PERSON) = TA.IMPAIR(*)
        LET TA.IMPAIR(*) = 0
        RESERVE TA.INCAP(*) AS N.AGENT
        LET T.AG.INCAP(PERSON) = TA.INCAP(*)
        LET TA.INCAP(*) = 0
        RESERVE AGA.DECON.DOSE(*) AS N.AGENT
        LET AG.DECON.DOSE(PERSON) = AGA.DECON.DOSE(*)
        LET AGA.DECON.DOSE(*) = 0
        RESERVE AGA.CUMDOSE(*) AS N.AGENT
        LET AG.CUMDOSE(PERSON) = AGA.CUMDOSE(*)
        LET AGA.CUMDCSE(*) = 0
        RESERVE AGA.LETH(*) AS N.AGENT
        LET AG.LETH(PERSON) = AGA.LETH(*)
        FOR J = 1 TO N.AGENT, LET AGA.LETH(J) = DISTRIB( D.LETH(J,*) )
        RESERVE AGA.IMPAIR(*) AS N.AGENT
        LET AG.IMPAIR(PERSON) = AGA.IMPAIR(*)
        FOR J = 1 TO N.AGENT, DO
            LET AGA.IMPAIR(J) = D.IMPAIR(J) * AGA.LETH(J)
        LOOP
        RESERVE AGA.INCAP(*) AS N.AGENT
```

CODE

```
            LET AG.INCAP(PERSON) = AGA.INCAP(*)
            FOR J = 1 TO N.AGENT, DO
                LET AGA.INCAP(J) = D.INCAP(J) * AGA.LETH(J)
            LOOP
            LIST NAME(PERSON), AGA.IMPAIR, AGA.INCAP, AGA.LETH
            LET AGA.IMPAIR(*) = 0
            LET AGA.INCAP(*) = 0
            LET AGA.LETH(*) = 0
            RESERVE A.ANTIDOTE(*) AS N.AGENT
            LET ANTIDOTE(PERSON) = A.ANTIDOTE(*)
            FOR J = 1 TO N.AGENT, LET A.ANTIDOTE(J) = 1      ''INITIALIZE
            LET A.ANTIDOTE(*) = 0
            RESERVE A.ROUND(*,*) AS 50 BY 2
            LET ROUND(PERSON) = A.ROUND(*,*)
            LET A.ROUND(*,*) = 0
            LET OLDX(PERSON) = X.CURRENT(PERSON)      ''INITIALIZE
            LET OLDY(PERSON) = Y.CURRENT(PERSON)
            LIST ATTRIBUTES OF PERSON
        LOOP
''READ IN AND ECHO GLOBAL INPUT VARIABLES
          CALL USER1.INPUT            ''PROBABILITIES & DISTRIBUTIONS
          CALL USER2.INPUT            ''PHYSICAL CONSTANTS
          LET UPTR(1) = 2             ''FOR UNIFORM(0,1) RANDOM DRAW
          LET UPTR(2) = 0
          LET UPTR(3) = 1
          LET AGENT.TYPE(1) = 1
          LET DELT = 10
          LET T.CURRENT = 130
          LET SOLDIER = PERSPTR(10)
''        FOR K = 1 TO 3, DO
          LET T.CURRENT = 110+ (DELT * 2)
          LET TL = T.CURRENT - DELT
          LIST T.CURRENT
''        FOR L = 1 TO 5, DO
          LET M = 2
          LET SOLDIER=PERSPTR(M)
          LET DEP.G.CURR(*) = DEP.GND(SOLDIER)          ''INITIALIZE
          LET DEP.A.CURR(*) = DEP.AIR(SOLDIER)
          LET PPA.CHEM(*) = PF.CHEM(SOLDIER)
          LET PPA.LEAK(*) = PF.LEAK(SOLDIER)
          LET TA.PF.CHEM(*) = T.PF.CHEM(SOLDIER)
          LET TA.IMPAIR(*) = T.AG.IMPAIR(SOLDIER)
          LET TA.INCAP(*) = T.AG.INCAP(SOLDIER)
          LET AGA.DECON.DOSE(*) = AG.DECON.DOSE(SOLDIER)
          LET AGA.CUMDOSE(*) = AG.CUMDOSE(SOLDIER)
          LET AGA.IMPAIR(*) = AG.IMPAIR(SOLDIER)
          LET AGA.INCAP(*) = AG.INCAP(SOLDIER)
          LET AGA.LETH(*) = AG.LETH(SOLDIER)
          LET A.ROUND(*,*) = ROUND(SOLDIER)
          LET A.ANTIDOTE(*) = ANTIDOTE(SOLDIER)
          LET SIDE = COLOR(SOLDIER) + 1
          LET DEPNUM(SOLDIER) = 5
          CALL CHEM.CHECK
          CALL LIST.ATTRIBUTES
''        LOOP
''LOOP
STOP
END     ''OF MAIN PROGRAM
```

CODE

```
ROUTINE USER1.INPUT
     RESERVE DT.PF(*,*,*,*) AS N.VEH.SYS.TYPE BY N.VEH.WPN.TYPE
         BY 7 BY 3
     RESERVE DT.MASK(*,*) AS N.SIDE BY 3
     RESERVE PC.MSKLEAK(*) AS N.SIDE
     RESERVE D.MSKLEAK(*,*) AS N.SIDE BY 3
     RESERVE DT.NAA(*,*) AS N.SIDE BY 3
     RESERVE PC.OHC(*) AS N.SIDE
     RESERVE DT.OHC(*,*,*) AS N.SIDE BY 3 BY 3
     RESERVE PC.ACT.OHC(*,*) AS N.SIDE BY 2
     RESERVE D.PF.LEAK(*,*,*) AS N.SIDE BY 7 BY 3
     RESERVE PC.IMM.DECON(*), PC.DEL.DECON(*) AS N.SIDE
     RESERVE PC.PF.LEAK(*,*) AS N.SIDE BY 7
     RESERVE PC.NAA(*) AS N.SIDE
     RESERVE DT.DETECT(*,*,*,*,*) AS 4 BY N.AGENT BY 5 BY 2 BY 3
     RESERVE PC.MASK(*), PC.MOPP(*) AS N.SIDE
     RESERVE DT.DECON(*,*,*,*) AS N.SIDE BY N.AGENT BY 7 BY 3
''
''READ IN AND ECHO GLOBAL INPUT VARIABLES
''
     READ DT.PF          ''DISTRIBUTION TIMES TO DON PROTECTIVE CLOTHING
     PRINT 1 LINE THUS
         ARRAY DT.PF
     FOR I=1 TO N.VEH.SYS.TYPE, FOR J=1 TO N.VEH.WPN.TYPE,
         FOR K=1 TO 7, DO
         PRINT 1 LINE WITH I, J, K, DT.PF(I,J,K,1),
             DT.PF(I,J,K,2), DT.PF(I,J,K,3) THUS
     I=**  J=**  K=**  **  **  **
     LOOP
     READ DT.MASK                 ''DISTR. OF MASKING TIMES
     LIST DT.MASK
     READ PC.MSKLEAK, D.MSKLEAK  ''PROB. & DISTR. OF MASK LEAKS
     LIST PC.MSKLEAK, D.MSKLEAK
     READ DT.NAA
     LIST DT.NAA
     READ PC.OHC, PC.ACT.OHC
''   LIST PC.OHC, PC.ACT.OHC
     READ DT.OHC
''   PRINT 1 LINE THUS
''       ARRAY DT.OHC
''   FOR K=1 TO N.SIDE, FOR L=1 TO 3, DO
''       PRINT 1 LINE WITH K, L, DT.OHC(K,L,1),
''           DT.OHC(K,L,2), DT.OHC(K,L,3) THUS
     K=**  L=**   ***.**  ***.**  ***.**
     LOOP
     READ D.PF.LEAK
     PRINT 1 LINE THUS
 ARRAY D.PF.LEAK
     FOR K=1 TO N.SIDE, FOR L=1 TO 7, DO
         PRINT 1 LINE WITH K, L, D.PF.LEAK(K,L,1),
             D.PF.LEAK(K,L,2), D.PF.LEAK(K,L,3) THUS
K=**  L=**    *.*  **.***  **.***
     LOOP
     READ PC.IMM.DECON, PC.DEL.DECON
     LIST PC.IMM.DECON, PC.DEL.DECON
     READ PC.PF.LEAK
     LIST PC.PF.LEAK
     READ PC.NAA
     LIST PC.NAA
     READ DT.DETECT               ''DISTR. OF CHEM. DETECTION PROBABILITIES
     PRINT 1 LINE THUS
         ARRAY DT.DETECT
     FOR I=1 TO 4, FOR J=1 TO N.AGENT, FOR K=1 TO 5,
         FOR L=1 TO 2, DO
         PRINT 1 LINE WITH I, J, K, DT.DETECT(I,J,K,1,1),
             DT.DETECT(I,J,K,1,2), DT.DETECT(I,J,K,1,3),
             DT.DETECT(I,J,K,2,1), DT.DETECT(I,J,K,2,2),
             DT.DETECT(I,J,K,2,3) THUS
     I=**  J=**  K=**  L=1  **  **  **     L=2  **  **  **
     LOOP
     READ PC.MASK, PC.MOPP
     LIST PC.MASK, PC.MOPP
     READ DT.DECON
     PRINT 1 LINE THUS
 ARRAY DT.DECON
     FOR K = 1 TO N.SIDE, FOR L = 1 TO N.AGENT, FOR I = 1 TO 7, DO
         PRINT 1 LINE WITH K, L, I, DT.DECON(K,L,I,1), DT.DECON(K,L,I,2),
         DT.DECON(K,L,I,3) THUS
 K = **  L = **  I = **  :  ****   ****   ****
     LOOP
 RETURN
 END     ''OF ROUTINE USER1.INPUT
```

CODE

```
ROUTINE USER2.INPUT
    RESERVE AG.DECAY(*) AS N.AGENT
    RESERVE MIN.G.CHEM(*), MIN.A.CHEM(*) AS N.AGENT
    RESERVE PF.MAX(*,*) AS N.SIDE BY 7
    RESERVE DEP.RED(*,*,*) AS N.AGENT BY 3 BY 2
    RESERVE AL.MAX.DIST(*), NAA.FACTOR(*) AS N.SIDE
    RESERVE ABS(*) AS N.AGENT
    RESERVE AG.AL.THRESH(*,*) AS N.SIDE BY N.AGENT
    RESERVE SKIN(*,*) AS N.SIDE BY 7
    RESERVE SW.NBC.FILTER(*,*,*,*,*,*) AS N.VEH.SYS.TYPE
      BY N.VEH.WPN.TYPE BY 2 BY 3 BY 2 BY N.AGENT
    RESERVE AG.INHAL.FACTOR(*), AG.PICKUP(*) AS N.AGENT
    RESERVE MULT.AG.DECON(*) AS N.SIDE
    RESERVE SW.BREATHING(*,*,*) AS N.VEH.SYS.TYPE BY N.VEH.WPN.TYPE BY 5
    RESERVE DCR(*) AS N.AGENT
    READ MIN.G.CHEM, MIN.A.CHEM   ''MINIMUM SIGNIFICANT GROUND AND
    LIST MIN.G.CHEM, MIN.A.CHEM     ''AIR DEPOSITIONS
    READ PF.MAX
    LIST PF.MAX
    READ DEP.RED
    PRINT 1 LINE THUS
        ARRAY DEP.RED
    FOR J = 1 TO N.AGENT, DO
        PRINT 1 LINE WITH DEP.RED(J,1,1),DEP.RED(J,1,2),DEP.RED(J,2,1),
  DEP.RED(J,2,2),DEP.RED(J,3,1),DEP.RED(J,3,2) THUS
    *.*** *.***        *.*** *.***       *.*** *.***
    LOOP
    READ SW.NBC.FILTER
    PRINT 1 LINE THUS
    ARRAY SW.NBC.FILTER
    FOR K = 1 TO N.VEH.SYS.TYPE, FOR L = 1 TO N.VEH.WPN.TYPE,
        FOR M = 1 TO 2, FOR N = 1 TO N.AGENT, DO
        PRINT 3 LINES WITH K,L,M,N,SW.NBC.FILTER(K,L,M,1,1,N),
   K,L,M,N,SW.NBC.FILTER(K,L,M,1,2,N),K,L,M,N,SW.NBC.FILTER(K,L,M,2,1,N),
   K,L,M,N,SW.NBC.FILTER(K,L,M,2,2,N),K,L,M,N,SW.NBC.FILTER(K,L,M,3,1,N),
   K,L,M,N,SW.NBC.FILTER(K,L,M,3,2,N) THUS
    SW.NBC.FILTER(**,**,*,1,1,*) = *.**    (**,**,*,1,2,*) = *.**
    SW.NBC.FILTER(**,**,*,2,1,*) = *.**    (**,**,*,2,2,*) = *.**
    SW.NBC.FILTER(**,**,*,3,1,*) = *.**    (**,**,*,3,2,*) = *.**
    LOOP
    READ AL.MAX.DIST
    LIST AL.MAX.DIST
    READ NAA.FACTOR
    LIST NAA.FACTOR
    READ AG.DECAY
    LIST AG.DECAY
    READ ABS
    LIST ABS
    READ AG.AL.THRESH
    LIST AG.AL.THRESH
    READ SKIN
    LIST SKIN
    READ AG.INHAL.FACTOR
    LIST AG.INHAL.FACTOR
    READ AG.PICKUP
    LIST AG.PICKUP
    READ MULT.AG.DECON
    LIST MULT.AG.DECON
    READ SW.BREATHING
    PRINT 1 LINE THUS
ARRAY SW.BREATHING
    FOR K = 1 TO N.VEH.SYS.TYPE, FOR L = 1 TO N.VEH.WPN.TYPE, DO
      PRINT 2 LINES WITH K,L,SW.BREATHING(K,L,1),K,L,SW.BREATHING(K,L,2),
      K,L,SW.BREATHING(K,L,3), K,L,SW.BREATHING(K,L,4),
      K,L,SW.BREATHING(K,L,5) THUS
SW.BREATHING(**,**,1) = **.**    (**,**,2) = **.**    (**,**,3) = **.**
SW.BREATHING(**,**,4) = **.**    (**,**,5) = **.**
    LOOP
    READ DCR
    LIST DCR
RETURN
END     ''OF ROUTINE USER2.INPUT
```

CODE

```
ROUTINE NUSSEII GIVEN T.CUR, X.CUR, Y.CUR, AND AG
     YIELDING DEP.GND AND DEP.AIR
     ''ROUTINE PROVIDES DEPOSITIONS FOR TESTING PROGRAM
     PRINT 1 LINE THUS
ROUTINE NUSEII CALLED
     NORMALLY, DIMENSION IS 0
     DEFINE T.CUR, X.CUR, Y.CUR, DEP.GND, DEP.AIR, ADEP, GDEP,
         XTHETA, YTHETA AS REAL VARIABLES
     DEFINE DEP.G AND DEP.A AS REAL, 2-DIMENSIONAL VARIABLES
     DEFINE AG, X AND Y AS INTEGER VARIABLES
     RESERVE DEP.G(*,*) AND DEP.A(*,*) AS 21 BY 21
     '' ELIMINATE ALL BUT ONE AGENT
''LIST AG, T.CUR
     IF AG IS NOT EQUAL TO 1, GO OUT
     '' START SIMULATED PATTERN AT T.CURRENT = 130
     OTHERWISE LET T.ROUND = 130
       IF T.CUR IS LESS THAN T.ROUND, GO OUT
       REGARDLESS LET DA = MAX.F( 0, (10-((T.CUR-T.ROUND)/DELT)))
       LET DG = MIN.F( 10, ((T.CUR-T.ROUND)/DELT))
       FOR X = 2 TO 20 , DO
          ''INITIALIZE GRID PATTERNLOWER BOUNDARIES
          LET DEP.A(X,1) = DA * ((X-1) +1)
          LET DEP.G(X,1) = DG * ((X-1) +1)
          ALSO FOR Y = 2 TO 20, DO
              LET DEP.A(1,Y) = DA * (1+ (Y-1))
              LET DEP.G(1,Y) = DG * (1+ (Y-1))
              '' SET UP REMAINING GRID PATTERN
              '' START SIMULATED PATTERN AT T.CURRENT = 130
              LET DEP.A(X,Y) = DA * (X+Y)
              LET DEP.G(X,Y) = DG * (X+Y)
              '' INTERPOLATE VALUE
              IF((X.CUR IS GE (X-1)) AND (X.CUR IS LT X) AND
                 (Y.CUR IS GE (Y-1)) AND (Y.CUR IS LT Y))
''LIST X.CUR, Y.CUR, X, Y
                  LET XTHETA = X.CUR - (X-1)
                  LET YTHETA = Y.CUR - (Y-1)
                  LET GDEP1 = DEP.G((X-1),(Y-1)) +
                         (XTHETA*(DEP.G(X,(Y-1))-DEP.G((X-1),(Y-1))))
                  LET GDEP2 = DEP.G((X-1),Y) +
                         (XTHETA*(DEP.G(X,Y)-DEP.G((X-1),Y)))
                  LET DEP.GND = 0.01 * (GDEP1 + (YTHETA*(GDEP2 - GDEP1)) )
                  LET ADEP1 = DEP.A((X-1),(Y-1)) +
                         (XTHETA*(DEP.A(X,(Y-1))-DEP.A((X-1),(Y-1))))
                  LET ADEP2 = DEP.A((X-1),Y) +
                         (XTHETA*(DEP.A(X,Y)-DEP.A((X-1),Y)))
                  LET DEP.AIR = 0.001 * (ADEP1 + (YTHETA*(ADEP2 - ADEP1)) )
              REGARDLESS
       LOOP
''LIST XTHETA, YTHETA
''LIST GDEP1,GDEP2,ADEP1,ADEP2
LIST DEP.GND, DEP.AIR
     RETURN
     'OUT'
     PRINT 1 LINE THUS
ROUTINE NUSSEII LEFT - AG NE 1 OR T.CUR LT 130
          LET DEP.GND = 0
          LET DEP.AIR = 0
          RETURN
END     ''OF NUSSEII ROUTINE
```

CODE

```
ROUTINE ARTILLERY.DRIVER
     IF T.CURRENT IS NOT EQUAL TO 130, RETURN
     OTHERWISE
     PRINT  1 LINE THUS
ROUTINE ARTILLERY.DRIVER CALLED
     FOR I = 1 TO 6, DO
         LET A.ROUND(I,1)  = 122            ''A BATTERY VOLLEY
         LET A.ROUND(I,2)  = 0              ''CONVENTIONAL
     LOOP
     FOR I = 7 TO 12, DO
         LET A.ROUND(I,1)  = 126            ''A BATTERY VOLLEY
         LET A.ROUND(I,2)  = 1              ''CHEMICAL
     LOOP
     LET RDPTR(SOLDIER)  = 12
     LET ROUND(SOLDIER)  = A.ROUND(*)
     RETURN
END     ''OF ROUTINE ARTILLERY.DRIVER
```

CODE

```
ROUTINE DISTRIB ( X )
     PRINT  1 LINE THUS
ROUTINE FUNCTION DISTRIB CALLED
     DEFINE X AS A REAL, 1-DIMENSIONAL ARRAY
     DEFINE ANSWER AS A REAL VARIABLE
     RESERVE X(*) AS 3
     GO TO DIST( X(1) )
'DIST(1)'     ''DETERMINISTIC
     LET ANSWER = X(2)
     GO OUT
'DIST(2)'     ''UNIFORM
     LET ANSWER = UNIFORM.F( X(2), X(3), 1)
     GO OUT
'DIST(3)'     ''NORMAL
     LET ANSWER = NORMAL.F( X(2), X(3), 1)
     LET ANSWER = MAX.F( 0, ANSWER )
     GO OUT
'DIST(4)'     ''LOGNORMAL
     LET ANSWER = LOG.NORMAL.F( X(2), X(3), 1)
     GO OUT
'DIST(5)'     ''EXPONENTIAL
     LET ANSWER = EXPONENTIAL.F( X(2), 1)
     GO OUT
'DIST(6)'     ''BETA
     LET ANSWER = BETA.F( X(2), X(3), 1)
     GO OUT
'OUT'
     RETURN WITH ANSWER
END     ''OF ROUTINE DISTRIB
```

C. VARIABLES REQUIRING USER INPUT

The variables listed below require user input. They are defined in the glossary; their use is documented in Chapter 3 and Appendix C.

1. Probabilities and Probability Distributions

NAME	TYPE	DIMENSION	MODE
D.MSKLEAK	GLOBAL VARIABLE	(2-D)	REAL
D.PF.LEAK	GLOBAL VARIABLE	(3-D)	REAL
DT.DECCN	GLOBAL VARIABLE	(4-D)	REAL
DT.DETECT	GLOBAL VARIABLE	(5-D)	REAL
DT.MASK	GLOBAL VARIABLE	(2-D)	REAL
DT.NAA	GLOBAL VARIABLE	(2-D)	REAL
DT.OHC	GLOBAL VARIABLE	(3-D)	REAL
DT.PF	GLOBAL VARIABLE	(4-D)	REAL
N.AGENT	GLOBAL VARIABLE		INTEGER
N.SIDE	GLOBAL VARIABLE		INTEGER
N.VEH.SYS.TYPE	GLOBAL VARIABLE		INTEGER
N.VEH.WPN.TYPE	GLOBAL VARIABLE		INTEGER
PC.ACT.OHC	GLOBAL VARIABLE	(2-D)	REAL
PC.DEL.DECCN	GLOBAL VARIABLE	(1-D)	REAL
PC.IMM.DECCN	GLOBAL VARIABLE	(1-D)	REAL
PC.MASK	GLOBAL VARIABLE	(1-D)	REAL
PC.MCPP	GLOBAL VARIABLE	(1-D)	REAL
PC.MSKLEAK	GLOBAL VARIABLE	(1-D)	REAL
PC.NAA	GLOBAL VARIABLE	(1-D)	REAL
PC.OHC	GLOBAL VARIABLE	(1-D)	REAL
PC.PF.LEAK	GLOBAL VARIABLE	(2-D)	REAL

2. Physical Constants and Characteristics

NAME	TYPE	DIMENSION	MODE
ABS	GLOBAL VARIABLE	(1-D)	REAL
AG.AL.THRESH	GLOBAL VARIABLE	(2-D)	REAL
AG.DECAY	GLOBAL VARIABLE	(1-D)	REAL
AG.INHAL.FACTOR	GLOBAL VARIABLE	(1-D)	REAL
AG.PICKUP	GLOBAL VARIABLE	(1-D)	REAL
AL.MAX.DIST	GLOBAL VARIABLE	(1-D)	REAL
DCR	GLOBAL VARIABLE	(1-D)	REAL
DEP.RED	GLOBAL VARIABLE	(3-D)	REAL
MIN.A.CHEM	GLOBAL VARIABLE	(1-D)	REAL
MIN.G.CHEM	GLOBAL VARIABLE	(1-D)	REAL
MULT.AG.DECON	GLOBAL VARIABLE	(1-D)	REAL
N.AGENT	GLOBAL VARIABLE		INTEGER
N.SIDE	GLOBAL VARIABLE		INTEGER
N.VEH.SYS.TYPE	GLOBAL VARIABLE		INTEGER
N.VEH.WPN.TYPE	GLOBAL VARIABLE		INTEGER
NAA.FACTOR	GLOBAL VARIABLE	(1-D)	REAL
PF.MAX	GLOBAL VARIABLE	(2-D)	REAL
SKIN	GLOBAL VARIABLE	(2-D)	REAL
SW.BREATHING	GLOBAL VARIABLE	(3-D)	REAL
SW.NEC.FILTER	GLOBAL VARIABLE	(6-D)	REAL

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